Rhodora

JOURNAL OF

THE NEW ENGLAND BOTANICAL CLUB

Vol. 45. **March, 1943.** **No. 531.**

CONTRIBUTIONS FROM THE GRAY HERBARIUM OF HARVARD UNIVERSITY—NO. CXLVII

THE BROAD-LEAVED SPECIES OF POTAMOGETON OF NORTH AMERICA NORTH OF MEXICO

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(Plates 746–748)

The genus *Potamogeton* is of world-wide distribution. Because it exhibits a great range of environmental variation, and specimens so often lack the fundamental diagnostic parts which might ally them with already known entities, the names that have been coined for its members are legion.

Although a number of monographic treatments have dealt with the North American species in whole or in part[1], the broad-leaved groups have been poorly understood. The really usable treatment of the troublesome linear-leaved species by Fernald lent new hope to the idea that possibly the broad-leaved plants

[1] Thomas Morong, The Naiadaceae of North America, Mem. Torr. Club **3**: no. 2 (1893).

P. Ascherson and P. Graebner, in Engler, Pflanzenr. **4**: fam. 11. Potamogetonaceae (Potamogeton by Graebner) (1907).

Norman Taylor, in N. Am. Fl. **17**: pt. 1 (1909).

J. O. Hagström, Critical Researches on the Potamogetons, Kungl. Svenska Vetenskapsakad. Handl. **55**: no. 5 (1916).

Harold St. John, A Revision of the North American Species of Potamogeton of the Section Coleophylli, Rhodora, **18**: 121–138 (1916).

M. L. Fernald, The Linear-leaved North American Species of Potamogeton, Section Axillares, Mem. Amer. Acad. Arts & Sci. **17**: pt. 1 (1932). As this work contains an excellent discussion of the previous treatments, an historical introduction would merely be repetitive and is unnecessary here.

might be resolved into something approaching an expression of their true relationships.

A fertile *Potamogeton* seldom causes great difficulty; but the great mass of sterile material, displaying a range of form unknown in the fertile plants, has made an understanding of the group difficult. To add to the confusion, the broad-leaved species, with their spikes buoyed up above the water, hybridize more or less freely, rendering it difficult in many cases to determine the fundamental cause behind the abnormality.

The following treatment is offered in the hope that the species here considered may be better understood; and that specimens may be properly identified, even though they lack many of the important diagnostic characters and exhibit forms that are far from typical.

Diagnostic Characters

Fruits. When mature fruits are present there is seldom any difficulty in referring the specimen to the proper species. Unfortunately the presence of fruit is not the rule but the less common occurrence. Most distinctive are those of *P. alpinus*, with a smooth, hard, eggshell-like exocarp, tawny-olive in color; fruiting specimens can never be mistaken for any other species. Neither can the minute reddish orbicular fruits of *P. polygonifolius* with their beaks practically obsolete, nor the massive fruits of *P. praelongus* be confused with those of any other North American broad-leaved species. The long-beaked fruits of *P. crispus* are especially characteristic. Extremely important diagnostic characters are the prominence of keels and the color of the exocarp. If one makes a longitudinal section with a razor-blade, the amount of curvature of the seed becomes apparent and is of some slight diagnostic value. More important in some cases, and surprisingly consistent, is the presence or absence of a cavity in the endocarp tissue that projects as a fold into the center of the fruit. This projection (endocarp loop) is solid in all the broad-leaved species except *P. polygonifolius*, *P. praelongus* and *P. Richardsonii*. This is an important character in the separation of *P. Richardsonii* from *P. perfoliatus*, specimens of which often strongly resemble each other. Because the fruits are of great taxonomic importance, but difficult adequately to describe, it has seemed desirable to illustrate them (see PLATE 746).

FLOWERS. It is now generally considered that *Potamogeton* has no true perianth. The sepal-like structures are thought to be outgrowths from the connectives of the stamens, and are called sepaloid connectives.[1] In the species here treated they are of little or no diagnostic value. Careful observations on the shape and hundreds of measurements on the width and length of claw have been made, from which it has become evident that even species which in most characters are strikingly different have sepaloid connectives which are surprisingly similar. The anthers, also, are of about the same shape and size in all the broad-leaved species, except that in *P. polygonifolius* they average somewhat smaller. Pollen-grains should be examined when hybridism is suspected. Fertile species have pollen-grains well formed and abundantly produced, whereas hybrids invariably have a large percentage aborted.

SPIKES. While the flowering spikes are of little diagnostic value, differing chiefly in average size and in number and degree of crowding of the whorls of flowers, the diameter of the fruiting spikes can be used. This thickness is almost entirely dependent on the length of the fruits, but in many cases the fruit-measurements cannot be so easily obtained. While there are some differences as to length of the spikes of different species, these are mostly a direct correlation with the robustness of the species, and their diagnostic value is therefore secondary.

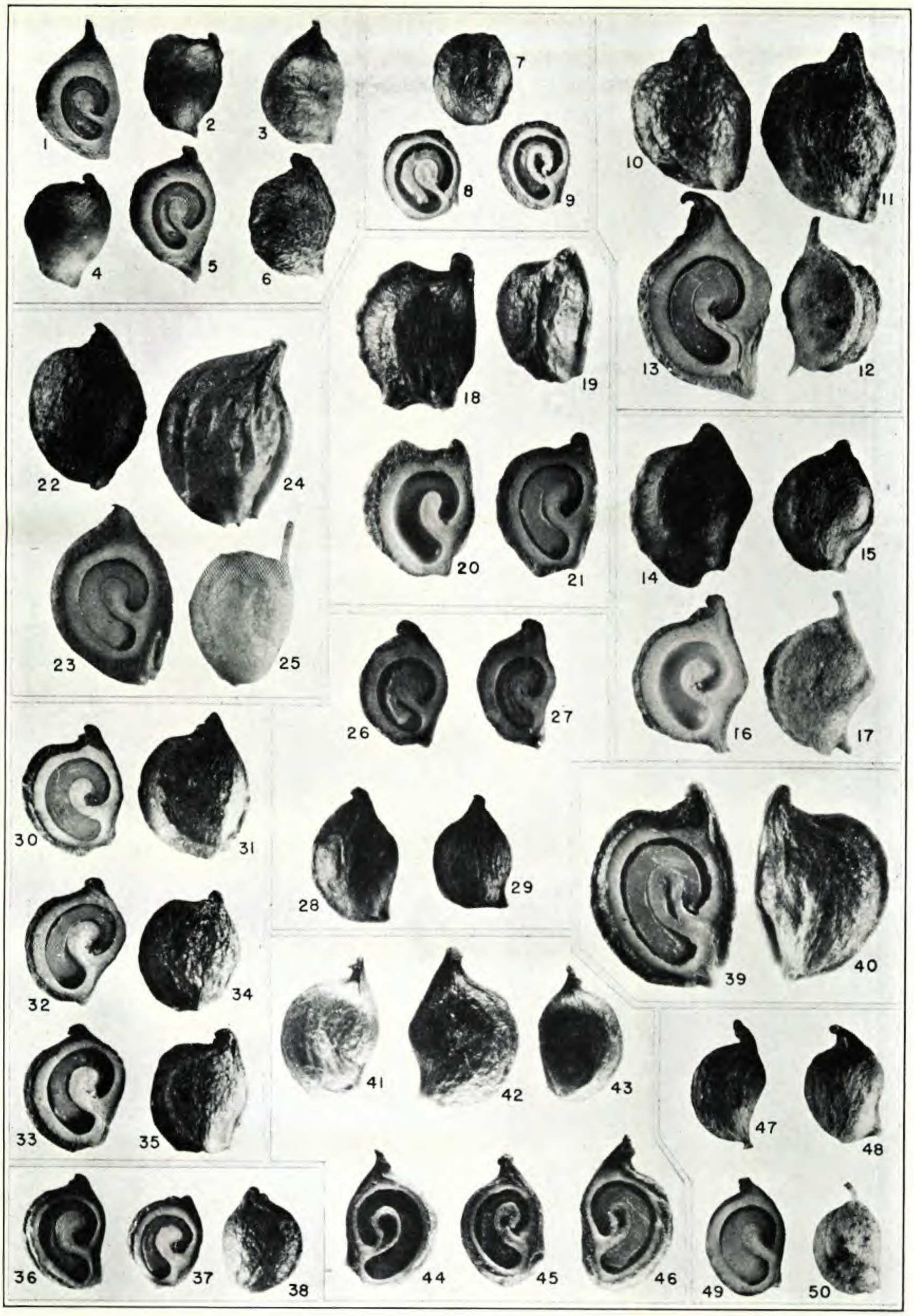
PEDUNCLES. Characters of the peduncle can usually not be used for the determination of broad-leaved species without supporting characters from other parts of the plant, due to the great variation within the same species, but they are sometimes of useful supplementary value. Most species seldom have peduncles over 10 or 15 cm. long, but in *P. amplifolius* they may run up to 30 cm. and it can then be distinguished from *P. pulcher* or *P. nodosus*, which at times it may superficially resemble. Similarly, *P. Richardsonii* may have peduncles up to 25 cm. in length, in contrast to its nearest relative, *P. perfoliatus*, with peduncles less than 10 cm. long. The longest peduncles are

[1] Phylogenists are not agreed on this. These structures may well represent a norma perianth with the anthers sessile on the claws of the segments.

found on *P. praelongus*, where they are often more than 30 cm. and may attain a length of 60 cm. The three species mentioned as sometimes having long peduncles (*P. amplifolius*, *P. praelongus*, and *P. Richardsonii*) may also have them short; but whether long or short, usually with a tendency to be clavate. This tendency for the peduncles to be thickened upward is also somewhat characteristic of the subsection *Lucentes*. Most of the species here treated have their peduncles rather uniform in thickness throughout their length. Another character of slight value is the thickness of a peduncle in comparison with the thickness of the stem at the internode directly below. This has some supplementary value in the subsection *Natantes*, where *P. natans* has peduncles about the same thickness as the stem, while *P. Oakesianus*, with its slenderer stem, has less reduction in the thickness of its peduncles, and as a consequence has them thicker than the internode below. Lastly, there are some differences in their internal anatomy. These are, however, few and inconstant and not used in this treatment.

Stipules. In all of the species here treated (with the exception of *P. crispus*) the stipules are free from the leaves. They clasp the stem, but have their margins absolutely free and ununited. They are all obtuse, at least when young, but as there is often a tendency for them to be somewhat cucullate they may, at times, appear to be acutish. This is especially true of *P. nodosus*. All are more or less two-keeled (when mature) except in the subsections *Crispi*, *Colorati*, *Praelongi*, and *Perfoliati*. The chief differences are in their length and coarseness, which are, for the most part, rather direct correlations with the robustness of the species. They furnish useful characters in the perfoliate-leaved species where one can usually recognize *P. praelongus* by its large white stipules, *P. Richardsonii* by its stipules reduced to strong white fibers, and *P. perfoliatus* with stipules delicate and inconspicuous.

Leaves. Certainly some of the most important diagnostic characters for the identification of the broad-leaved species of *Potamogeton* are to be found in the leaves, for too often all that are available are stems and either submersed or floating leaves, or both. At least three fourths of the specimens in the herbaria lack not only mature fruits but any part of an inflorescence.



FRUITS OF POTAMOGETON, × 5

P. ALPINUS var. TENIFOLIUS, figs. 1–3; P. ALPINUS var. SUBELLIPTICUS, figs. 4–6; P. POLYGONIFOLIUS, figs. 7–9; P. AMPLIFOLIUS, figs. 10–13; P. PULCHER, figs. 14–17; P. NODOSUS, figs. 18–21; P. NATANS, figs. 22–25; P. OAKESIANUS, figs. 26–29; P. ILLINOENSIS, figs. 30–35; P. GRAMINEUS, figs. 36–38; P. PRAELONGUS, figs. 39 and 40; P. RICHARDSONII, figs. 41–46; P. PERFOLIATUS var. BUPLEUROIDES, figs. 47–50.

The stipules often shrivel and decay, so that the few remnants (if any are left) are insufficient for diagnostic purposes. Rhizomes are seldom collected and when present are of but slight taxonomic value. Thus, unless one resorts to the internal anatomy of the stem, it is, in the great majority of cases, necessary to determine the specimens from the leaves. These may be either submersed or floating, or both, in all the subsections except *Crispi*, *Praelongi*, and *Perfoliati*, which have only submersed leaves. These three subsections always have sessile perfoliate-clasping leaves[1] with broad bases in contradistinction to the other subsections which have their submersed leaves petioled or at least narrow at base.

First considering the submersed leaves: their shape is of primary importance. When typically developed, *P. perfoliatus* can be recognized immediately by its short-ovate leaves; *P. Richardsonii* by having them ovate-lanceolate; *P. praelongus* with them oblong and cucullate at the apex; the members of the *Lucentes* by the sharp-pointed apices; *P. natans* and *P. Oakesianus* by their coarse and delicate, narrowly linear leaves, respectively; *P. nodosus* by its long-petioled lanceolate leaves gradually tapering at both ends; *P. pulcher* having distinctive lanceolate leaves abruptly tapering to a petioled base; *P. amplifolius* with its massive leaves conspicuously arcuate; and *P. alpinus* with obtuse apex and sessile base. Unfortunately, however, it is not always as simple as that. These leaves exhibit such a wide range of variation[2] from the typical and are often in such a poor state of preservation, if not entirely absent, that one must resort to other parts of the plant for diagnostic characters. The leaf-margin of *P. crispus* is finely but evidently toothed; in the other broad-leaved species the leaf-margins are strictly entire, except in the *Nodosi*, which have 1-celled denticles so extremely fugacious as to be found only in the youngest leaves; the *Perfoliati*, in which the 1-celled denticles are more persistent; and the *Lucentes*, with strongly developed denticles. None of the indigenous North American species with free stipules has a dentation visible to the unaided eye, consequently they should

[1] The hybrid *P. gramineus* × *perfoliatus* var. *bupleuroides* may have perfoliate submersed leaves and also floating leaves.

[2] See discussion under VARIATION.

never be confused with *P. crispus*, a species naturalized from Europe, which has an evident serrulation.

Turning to the floating leaves, we find at first glance a discouraging similarity. With the exception of *P. alpinus*, which has delicate, lacunate floating leaves the blades of which taper without sharp distinction into the petiole, all seem to possess the common ovate-elliptic shape and have the same blunt mucro at the apex. When typically developed, however, we find some help in the bases of the blades. Their shape ranges from cordate in *P. natans* and *P. pulcher* to rounded in *P. Oakesianus* and *P. amplifolius* to cuneate in *P. nodosus* to tapering without sharp distinction into the petiole in *P. alpinus*. Yet, the range of variation is so great in any one species that the shape of the leaf-base must be used with caution. Even *P. natans* with its strongly cordate leaf-bases may under certain conditions have them narrowly cuneate.[1] The number of nerves is of primary importance in the case of *P. amplifolius*, which has them very numerous and close together. The size and shape of the stomates appear to be rather uniform, and while there is some variation as to the number in a given field, this appears to be influenced by factors which are ecological rather than genetic. Examination as to number and condition (whether functional or closed by cuticle) may be useful in determining whether the abnormality of some floating leaves is due to genetic or to ecological factors.

STEM. For a genus which varies so considerably due to ecological conditions, and which is so often found lacking parts that have the essential diagnostic characters, it is exceedingly fortunate that there are good characters in the anatomy of the stem. These were apparently first noticed and their importance realized by Raunkiaer[2] who used them in his studies on the Danish species and then extended his "anatomical investigations also to foreign species, intending to bring about a new and better basis for an eventual monograph of the genus *Potamogeton*."[3] In 1907, Chrysler[4] elaborated further on the anatomy of the

[1] See discussion under P. NATANS.

[2] C. Raunkiaer, De danske Blomsterplanters Naturhistorie, Bind 1, Enkimbladede, p. 32–110 (1895–1899).

[3] C. Raunkiaer, Anatomical Potamogetón-Studies and *Potamogeton fluitans*, Bot. Tids. **25**: 254 (1903).

[4] M. A. Chrysler, Bot. Gaz. **44**: 161–188 (1907).

central cylinder, explaining the phylogenetic relationships of the various types. Hagström in his monograph[1] emphasized the taxonomic value of the anatomical characters, especially of the stem, laying great stress on the types of endodermi, of which he described six kinds, and on the arrangement of bundles in the stele of which he described and illustrated six patterns. Other characters used by him include: the development of mechanical tissue, the presence or absence of a cortical layer directly beneath the epidermis and acting as a supporting layer to it (hypoderma), and the length in proportion to width of the cells of the epidermis.

An examination of hundreds of stems has shown that a number of the characters have real diagnostic and phylogenetic value. These are discussed below.[2] Although it has been suggested that the extent of mechanical tissue present is dependent on whether the plant grows in still or running water,[3] Raunkiaer[4] and Chrysler[5] show that no such correlation can be drawn. Hagström, too, in his Critical Researches, repeatedly shows for many species that the habitat does not affect the essential characters of the stem-anatomy. An aquarium-plant of *P. natans* which I grew from a seed had its mechanical development not at all lessened.

A morphological character of some importance is the degree of branching of the stem. The members of the subsections *Lucentes* and *Perfoliati* are usually much branched; *P. praelongus* of the *Praelongi* and *P. Oakesianus* of the *Natantes* are commonly branched; *P. natans* of the *Natantes* and the members of the *Nodosi*, *Amplifolii*, *Colorati* and *Alpini* are rarely branched, and then usually only slightly so in the upper part of the plant late in the season.

The rhizome appears to offer no important diagnostic characters, at least when dried. Some species tend to have dark-colored (usually reddish) spots on their rhizomes, while others are unspotted, but this is rather inconstant.

[1] J. O. Hagström, Crit. Res. Pot. (1916).

[2] See Explanation of Stem-anatomy Characters used in this Treatment.

[3] S. Schwendener, Das mechanische Princep in anatomischen Bau der Monocotylen, p. 122 (1874).

[4] C. Raunkiaer, Bot. Tids. 25: 275 (1903).

[5] M. A. Chrysler, Bot. Gaz. 44: 169 (1907).

WINTER BUDS. With the exception of *P. crispus*, winter buds are so uncommon among the species here treated as to be of little or no diagnostic value. They have been so ably discussed by Professor Fernald[1] that further remarks are quite unnecessary.

VARIATION

It is well known that in vegetative characters any broad-leaved species of *Potamogeton* varies considerably. Those of the subsections *Lucentes* and *Perfoliati* have a wide range of variation and all of the species here treated have a variability which is evident. Morong bewailed this characteristic of the group and felt that "so protean are their forms, so eccentric their action, constantly changing under changed conditions of season and water" that he must put forth his treatment "with great diffidence".[2] Chamisso and Schlechtendal[3] had earlier reached the conclusion that, to use the translation of Emmeline Moore[4], "Species of Potamogeton changing their habit seem often to pass into others, and feigning the habit of other species baffle research."

Certain of these differences in form are undoubtedly genetic, but for many the evidence that they are ecological is very strong. Numerous observations and experimental studies have shown that individual plants of certain of the broad-leaved species exhibit a variation that is almost unbelievably wide, not only including many named varieties but even simulating other species. Noteworthy among such experimental studies are those of Esenbeck,[5] whose great contribution from the standpoint of taxonomy was in demonstrating that leaf-shape varies greatly under varying conditions of nutrition and changes of water-level. In general, poor nutrition appeared to give the following sequence of events: the broad floating leaves become increasingly narrower, finally disappear and are replaced by the submerged type, which in turn may be reduced to phyllodia.

[1] M. L. Fernald, Mem. Am. Acad. Arts & Sci. **17**: pt. 1: 18 (1932).

[2] Thomas Morong, Mem. Torr. Club **3**: no. 2: 2 (1893).

[3] Chamisso and Schlechtendal, Linnaea, **2**: 159 (1827).

[4] Emmeline Moore, The Potamogetons in Relation to Pond Culture, Bull. Bur. Fish. **33** (1913): 256 (1915).

[5] Ernst Esenbeck, Beiträge zur Biologie der Gattungen Potamogeton und Scirpus, Flora **107**: 151–211 (1914).

Fryer's experiments with the broad-leaved species which he grew in tubs caused him to prefer a very conservative treatment of the group.

Of outstanding importance in this connection is the work of the Pearsalls[1] who found that variation in size and shape of leaf was due to many factors, acting independently or together. Their results led them to the conclusion that a conservative treatment is the sane one.

While it is known that many of the variations are strictly ecological and one can in many cases name the contributing stimuli, it must be admitted that certain of these differences in form may be genetic. It is often difficult to distinguish from herbarium specimens alone which is the primary cause. When such variants appear to be mere forms or states, without separate geographic ranges, and especially when it is reasonable to suppose that the variations might be caused by ecological factors, it seems wise to refrain from giving them formal rank in our system of nomenclature. In the words of Fryer, "we should not confound temporary states with permanent varieties . . . In looking over an extensive series of dried specimens of any Potamogeton, it is easy to select very distinct looking forms, and as easy to give varietal names to them; this is the method that has been followed by most of the writers on the genus, and I regret to say is still being followed, with the result of confusing rather than elucidating an already too difficult subject."[2]

Hybridism

In dealing with broad-leaved species of *Potamogeton*, one is dealing with plants that are usually sterile, which are highly susceptible to ecological variation and which hybridize freely.

If one classifies all the fruiting specimens, then correlates with them all the sterile plants the vegetative parts of which show their relationships to the fruiting entities, one still has a great mass of material that fits nowhere. Any attempt to understand such material must determine for each specimen whether the variation is genetic or ecological or due to hybridism. Here the internal anatomy of the stem will prove of great assistance and

[1] W. H. Pearsall & W. H. Pearsall, Journ. Bot. 61: 1–7 (1923).

[2] Alfred Fryer, Pot. Brit. Isles, p. 41 (1900).

often will allow the specimen to be rather definitely placed. But many times the stem-anatomy shows an upset; this points toward hybridism, for the species based on fruiting specimens show a stem-anatomy that is remarkably uniform, and repeated observations have shown that ecological factors do not affect the anatomical characters of the stem; neither will minor genetic variations. But one cannot merely say "hybrid," as an easy way out of a difficulty; one should name the parents, usually not an easy thing to do.

Whether experimental studies will produce data of value in this connection, I am not prepared to say. Hagström thought not, saying, "The hybrids must be studied according as Nature produces them. Cultivation and experiments in hybridization may not lead to great results as to the solution of this intricate question."[1] To this, Bennett retorts, "having seen the results of the late Alfred Fryer's work in this direction, I consider cultivation is a very great help—anyhow it affords a negative to some of the proposed hybrids given."[2]

Very little seems to be known about the chromosome number of *Potamogeton*. Wiegand[3] reported a haploid number of seven, or possibly eight, for *P. foliosus*. Wisniewska[4] states that the haploid number for *P. perfoliatus* is probably ("wahrscheinlich") twenty-four. The only other reported count is in Tischler,[5] where the haploid number for *P. fluitans* (*P. nodosus*?) is given as twenty-six, referring to Kuleszanka 1934, without citing any publication. Such data promise interesting results from counts on the species in this genus.

Cytological material (young pollen) of several species which I have examined shows that the chromosome number varies (at least four different numbers) in different species, although absolute counts could not be made.

In the present work, the hybrids are taken up at the end of the general treatment. Only those that strongly simulate the subsections here specially treated are discussed.

[1] J. O. Hagström, Crit. Res. Pot. 12 (1916).
[2] A. Bennett, Journ. Bot. **55**: 115 (1917).
[3] K. M. Wiegand, Bot. Gaz. **28**: 328–359 (1899).
[4] Ewa Wisniewska, Acta Societatis Botanicorum Poloniae **8**: 157 (1931).
[5] G. Tischler, Tab. Biol. Period. 5 & 6, Nachtrag no. 2, Teil no. 2, p. 99 (1935–36).

Acknowledgments

In a study of this nature I have naturally found it convenient to accept the assistance and suggestions so kindly offered by many people. I am especially grateful to Prof. M. L. Fernald under whose guidance the study was conducted and who, by his clear knowledge of the difficulties involved, offered invaluable suggestions. Also to Mr. C. A. Weatherby for his helpful advice, especially concerning nomenclature, I am deeply thankful. Thanks are also due to the members of the Gray Herbarium staff who have so willingly helped with various details; to Prof. F. H. Steinmetz, of the University of Maine, who has taken a keen interest in the work and has assisted greatly in the collecting of material; to my wife, Edith B. Ogden, for assistance in many ways; and to the curators of the herbaria from which plants have been borrowed.

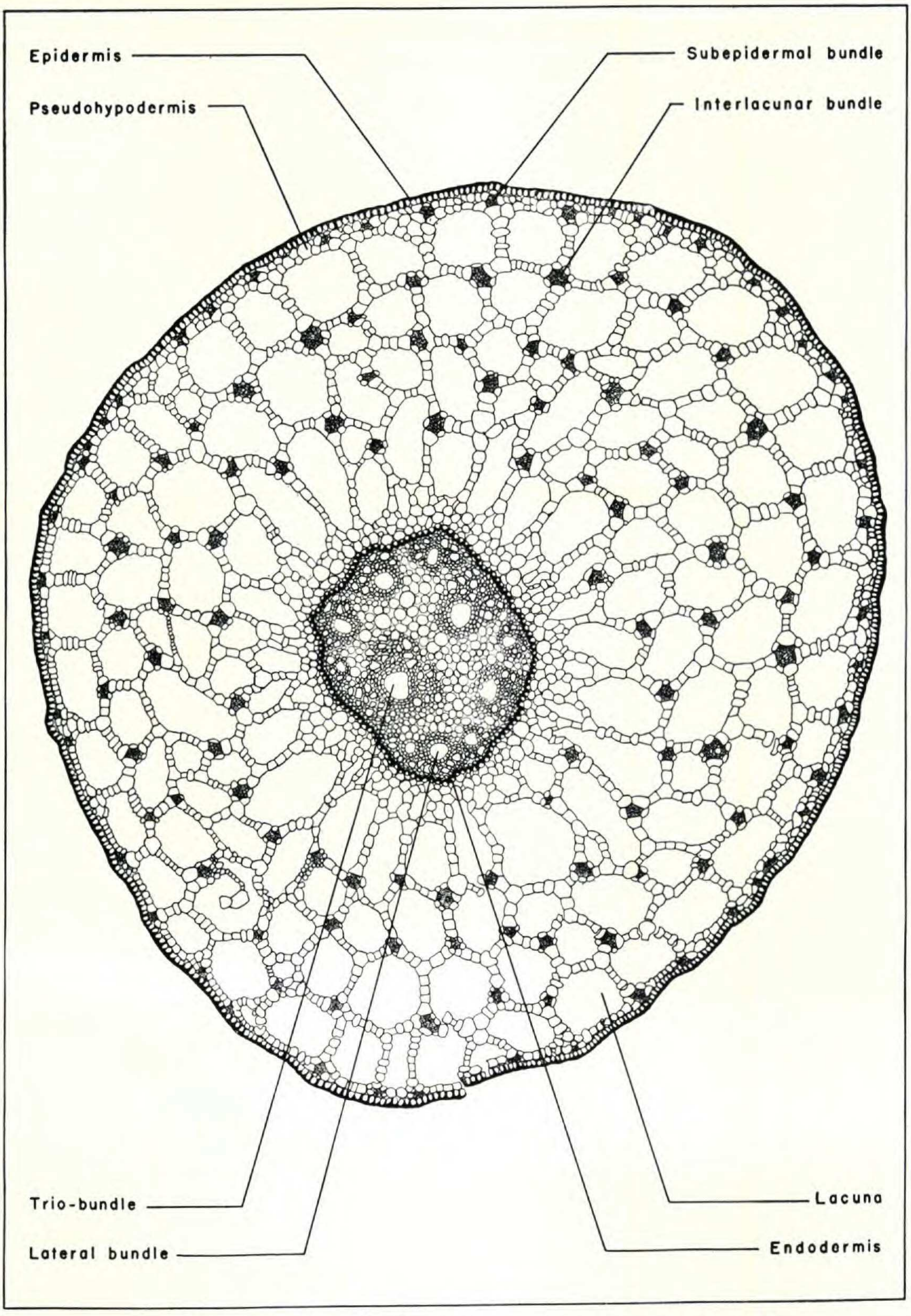
Herbarium material has been seen from the following sources: Gray Herbarium (G), New England Botanical Club (NE), New York Botanical Garden (NY), United States National Museum (US), Field Museum (F), Missouri Botanical Garden (M), Dudley Herbarium, Stanford University (S), Michigan State College (MSC), National Museum, Ottawa, Canada (C), University of Montreal (MT), Private herbarium of Marie-Victorin (V), University of Maine (ME), Portland [Maine] Society of Natural History (P), University of New Hampshire (NH), C. C. Deam (D), private herbarium, E. C. Ogden (O).

Explanation of Stem-anatomy Characters used in this Treatment

Five sets of characters are used, combinations of which should determine the species. These are: the arrangement of bundles in the stele, the type of thickening of the cells of the endodermis, the presence or absence of bundles in the interlacunar spaces of the cortex (interlacunar bundles), the presence or absence of bundles just underneath the epidermis (subepidermal bundles), and the presence or absence of a layer or layers of cells directly underneath the epidermis (pseudo-hypodermis). See PLATE 747.

One of the most important sets of characters is that of the arrangements of bundles in the stele. These fall into six types. The arrangement called the proto-type (because it appears to be the type from which the others are derived) is illustrated by PLATE 748, FIG. 1. Here the bundles are all free and un-united (each having one patch of phloem), four of them being median and with usually three to five on each side. When this arrangement is found, the specimen will belong to one of the subsections: *Colorati, Amplifolii, Lucentes,* or *Praelongi*. In the trio-type (FIGS. 2 & 3) three of the median bundles have united to form a bundle "trio", giving only two median bundles, one of them with a patch of phloem on the outer face of the xylem canal and two patches of phloem on the inner face (FIG. 2), or by a further union having only one inner patch of phloem (FIG. 3). The trio-type is always found in the subsections: *Alpini, Nodosi, Natantes* and *Perfoliati*. Members of the subsection *Lucentes* may also have the trio-type of stele. A further reduction in the number of bundles is brought about by the fusion of the lateral bundles and as this invariably results in an oblong-shaped stele it is called the oblong-type. The two median bundles may remain separate (FIG. 4) and even the lateral bundles may at times be scarcely united but merely crowded together. The oblong-type with two median bundles is found in the subsection *Lucentes*, and is prevalent in hybrids having a member of the *Lucentes* as one of the parents. A fusion of the two median bundles is accompanied by the more or less complete fusion of the laterals on each side, resulting in a stele of an oblong (or elliptic) shape with but three bundles (FIG. 5). This is the usual type in the subsections *Crispi* and *Lucentes*. The final reduction to the one-bundled-type (FIG. 6) is not met with in the broad-leaved species, but is found in the hybrid *P. Berchtoldi* × *perfoliatus* var. *bupleuroides*.

The cells of the endodermis give an important set of diagnostic characters. Although several types can be recognized, these have been grouped in the present treatment into two principal types, according to the type of incrassation of the cell-walls. Cells which are thickened evenly or not at all are called O-cells; those which are much thickened on the inner and lateral faces but remain thin on the face next to the cortex are called U-cells. This latter type of endodermis is always found in the *Natantes*,



POTAMOGETON NATANS: CROSS-SECTION OF STEM, × 35

Lucentes, and *Praelongi.* All the others here treated have O-cells.

The bundles of the cortex give exceptionally good sets of characters. The cortex of a *Potamogeton* stem is highly lacunate. At the junctures of the walls separating these lacunae may, in some species, be found bundles composed of vascular tissue and fibers or merely of fibers alone. These are called interlacunar bundles and are well developed in the *Natantes, Lucentes, Praelongi,* and in *P. amplifolius* of the *Amplifolii.* The other subsections are devoid of them, or rarely have one or two weakly developed.

The cortical bundles found directly underneath the epidermis are called subepidermal bundles. They are seldom as strongly developed as the interlacunar bundles, yet they furnish a set of characters which is quite useful. The subepidermal bundles are present in the *Colorati, Natantes, Praelongi,* and usually in the *Lucentes,* but absent in the other subsections.

The last set of characters used is the presence or absence of a layer or layers of cells directly beneath and adjacent to the epidermis. This is called the pseudo-hypodermis. It is always present in the *Crispi, Amplifolii, Praelongi,* and *Perfoliati,* but is not present in the *Alpini* and *Nodosi,* whereas the *Colorati, Natantes,* and *Lucentes* may or may not have it.

A number of methods of preparing a section of stem for anatomical examination may be used. The following procedure has been found to be simple and rapid and highly satisfactory. When a choice can be made as to the part of the stem to be sectioned it should be at about the middle of the second or third internode below the lowest peduncle. However, any portion of the stem, if not too close to a node, is usually quite satisfactory. The piece of stem is boiled in water for a few minutes to soften and expand the tissues, then dropped into cold water to reduce flabbiness. A clean transverse cut is made near one end with a sharp razor-blade and this end dipped into ordinary blue ink, or other stain, for a second or two. The stem is now rinsed briefly in cold water and rolled on a blotter to remove excess water. With the razor-blade a thin free-hand section is taken off at the stained end, a water-mount made (stained end up), and examined under a microscope. If the stem is badly flattened, it can be teased out with fine needles. A magnification of about 100 diameters is highly satisfactory, although much lower powers will enable one to determine most of the essential characters. Such mounts need not be thinner than that obtainable by free-hand sectioning, for enough light will come through the lacunae to illuminate the tissues.

The amount of time necessary for making an anatomical examination of a stem need not be greater than that necessary for boiling and dissecting a flower.

A number of improvements can undoubtedly be made on this method, but mostly at the sacrifice of simplicity and speed. Potassium hydroxide solution is not recommended for swelling the tissues as it destroys the delicate cortex. A weak lactic acid solution will soften tissues quickly and swell them slightly without destroying the cortex, but for most specimens water is more satisfactory. If cold water does not stiffen the material sufficiently for proper sectioning, a few drops of concentrated ammonia in the water are helpful.

Ordinary blue fountain-pen ink is suggested as a stain because it is easily available and has proved very satisfactory. It acts quickly and as a differential stain: coloring the vascular tissue deep blue and the cortical and pith cells light blue; the mechanical tissue (sclerenchyma) usually remaining a bright yellow and the endodermis usually yellow or orange. The clearer results obtained by aniline dyes are not necessary for this work. A two-solution differential stain is not recommended for speedy examination.

The Classification of North American Pondweeds

In order that the groups of *Potamogeton* here specially discussed may be properly oriented, an outline (largely following Hagström and Fernald) of the relationships of North American species is here appended. The subsections treated in this paper are indicated by asterisks.

Subgenus Coleogeton (Reichenb.) Raunk.
  Section Connati Hagstr.
    Subsect. Filiformes Hagstr. (*P. filiformis* Pers., *P. latifolius* (Robbins) Morong).

Section CONVOLUTI Hagstr.
Subsect. VAGINATI Hagstr. (*P. vaginatus* Turcz.).
Subsect. PECTINATI (Fries) Hagstr. (*P. pectinatus* L.).
Subgenus EUPOTAMOGETON Raunk.
Section ADNATI Hagstr.
Subsect. SERRULATI Hagstr. (*P. Robbinsii* Oakes).
Section AXILLARES Hagstr.
*Subsect. CRISPI Wallm. (*P. crispus* L.).
Subsect. MONTICOLI Hagstr. (*P. confervoides* Reichenb.).
Subsect. COMPRESSI (Fries) Hagstr. (*P. zosteriformis* Fern.).
Subsect. OXYPHYLLI Hagstr. (*P. Porsildiorum* Fern., perhaps also *P. longiligulatus* Fern.).
Subsect. PUSILLI (Graebn.) Hagstr.
Series PUSILLI CONNATI Hagstr.
Subseries FOLIOSI Fern. (*P. foliosus* Raf., *P. fibrillosus* Fern.).
Subseries PANORMITANI Fern. (*P. Friesii* Rupr., *P. strictifolius* Ar. Benn., *P. pusillus* L.).
Series PUSILLI CONVOLUTI Hagstr.
Subseries ACUTI Hagstr. (*P. gemmiparus* Robbins, *P. Hillii* Morong; *P. longiligulatus* Fern., an atypical species, may belong in the *Oxyphylli*).
Subseries OBTUSI Hagstr. (*P. Porteri* Fern., *P. obtusifolius* Mert. & Koch, *P. clystocarpus* Fern., *P. Berchtoldi* Fieber).
Subsect. JAVANICI Graebn. (*P. Vaseyi* Robbins, *P. lateralis* Morong).
Subsect. HYBRIDI (Graebn.) Hagstr., in part; *i. e.*
Series EUHYBRIDI Hagstr. (*P. Spirillus* Tuckerm., *P. diversifolius* Raf., *P. capillaceus* Poir., *P. bicupulatus* Fern.).
Subsect. NUTTALLIANI (Hagstr.) Fern. (*P. epihydrus* Raf., *P. tennesseensis* Fern.).
*Subsect. ALPINI (Graebn.) Hagstr. (*P. alpinus* Balbis).
*Subsect. COLORATI (Graebn.) Hagstr. (*P. polygonifolius* Pourr.).
*Subsect. AMPLIFOLII Hagstr. (*P. amplifolius* Tuckerm., *P. pulcher* Tuckerm.).
*Subsect. NODOSI Hagstr. (*P. nodosus* Poir.).
*Subsect. NATANTES Graebn. (*P. natans* L., *P. Oakesianus* Robbins).
*Subsect. LUCENTES Graebn. (*P. gramineus* L., *P. illinoensis* Morong).
*Subsect. PRAELONGI Hagstr. (*P. praelongus* Wulfen).
*Subsect. PERFOLIATI (Graebn.) Hagstr. (*P. Richardsonii* (Benn.) Rydb., *P. perfoliatus* L.).

KEY TO THE BROAD-LEAVED NORTH AMERICAN SPECIES OF POTAMOGETON

1. Stem laterally compressed; leaves all submersed, margins toothed; stipules slightly adnate to base of leaf; fruits with beak 2–3 mm. long; winter buds hard and horny; stele of the oblong-type pattern; endodermis of O-cells; interlacunar bundles absent.[1] (subsect. CRISPI) . . . . 1. *P. crispus.*
1. Stem terete; leaf-margins entire or minutely denticulate; stipules completely free from leaf-base; fruits with beak not more than 1 mm. long; winter buds rare, not hard and horny; stele with the pattern various in type; if of the oblong-type, then endodermis of U-cells and interlacunar bundles present. . . . 2.
  2. Submersed leaves petioled or tapering to a sessile base, scarcely clasping; floating leaves present or absent. . . . 3.
    3. Submersed leaves sessile; floating leaves (usually absent) delicate, translucent, tapering without sharp distinction into the petiole; fruits with exocarp hard and smooth, tawny-olive (subsect. ALPINI) . . . . 2. *P. alpinus.*
    3. Submersed leaves sessile or petioled; floating leaves coriaceous, opaque, cordate to cuneate at base, blade distinct from petiole; fruits with exocarp soft and porous, greenish, brownish, or reddish. . . . 4.
      4. Sepaloid connectives 1–2 mm. wide; fruiting spikes 5–7 mm. thick; fruits 1.6–2.5 mm. long, keels rounded or none, beak obsolete or nearly so, endocarp loop usually with a cavity; interlacunar bundles absent; subepidermal bundles present; eastern Newfoundland and Sable Island, Nova Scotia (subsect. COLORATI) . . . . 3. *P. polygonifolius.*
      4. Sepaloid connectives mostly 1.2–3 mm. wide; fruiting spikes 6–15 mm. thick; fruits mostly 2–5 mm. long, keels variable, beak evident, endocarp loop solid; interlacunar bundles absent or present; if absent, then subepidermal bundles absent; widespread. . . . 5.
        5. Submersed leaves broadly linear, lanceolate, or ovate, less than 30 times as long as broad, nerves 3–37; stele with the pattern various in type; if of the trio-type, then with but 1 patch of phloem on the inner face of the trio-bundle. . . . 6.
          6. Submersed leaves with 11–37 nerves, margins strictly entire; floating leaves cordate to rounded at base, nerves mostly more than 21; stele with the proto-type pattern; endodermis of O-cells (subsect. AMPLIFOLII). . . . 7.
            7. Stem not conspicuously black-spotted; submersed leaves usually arcuate, 2.5–7.5 cm. wide; floating leaves cuneate or rounded at base, mostly with more than 30 nerves, about ¼ of the nerves more prominent than the rest as seen by transmitted light; peduncles often clavate; fruits cuneate at base, 3.5–4.5 (–5) mm. long; interlacunar bundles present 4. *P. amplifolius.*
            7. Stem usually conspicuously black-spotted; submersed leaves not arcuate, 1–2.5 cm. wide;

[1] Anatomical characters refer to those of the stem. See p. 67 and keys on pages 75 and 77–85.

floating leaves cordate or rounded at base, mostly with less than 30 nerves, all nerves of about equal prominence as seen by transmitted light; peduncles not conspicuously clavate; fruits rounded or lobed at base, 3–3.5 (–4) mm. long; interlacunar bundles absent . . . . 5. *P. pulcher.*

6. Submersed leaves with 3–29 nerves, margins with fugacious one-celled translucent denticles; floating leaves cuneate to rounded at base, their nerves mostly less than 21; stele with the pattern various in type; if of the proto-type pattern, then endodermis of U-cells. . . . 8.

8. Submersed leaves with petioles 2–13 cm. long, apex acutish but not sharp-pointed nor mucronate; fruits 3.5–4 mm. long, usually reddish, keels mostly muricate; endodermis of O-cells; interlacunar bundles absent (subsect. Nodosi) . . . . 6. *P. nodosus.*

8. Submersed leaves sessile or with petioles up to 4 cm. long, apex acutish or sharp-pointed, often somewhat mucronate; fruits 1.7–3.5 mm. long, usually greenish, keels scarcely muricate; endodermis of U-cells; interlacunar bundles present (subsect. Lucentes) . . . . 9.

9. Stem usually much branched, .5–1 mm. in diameter; submersed leaves .2–1 (–1.5) cm. wide, (5–) 7–12 (–30) times as long as wide, sessile, nerves mostly 3–9; floating leaves 1.5–5 (–7) cm. long, 1–2 (–3) cm. wide, petioles mostly longer than the blades; stipules .5–3 cm. long, .1–.2 mm. wide, keels faint; peduncles clavate or not; fruiting spikes 1–2.5 cm. long, .6–.8 cm. thick; sepaloid connectives mostly 1.2–1.6 mm. wide; fruits 1.7–2.5 (–2.8) cm. long, 1.6–2 (–2.3) cm. wide; stele of the oblong-type pattern with 1 (rarely with 2) central bundles and 1 lateral bundle on each side; interlacunar bundles only in the outer interlacunar circle . . . . 9. *P. gramineus.*

9. Stem simple or once branched, (1–) 1.5–5 mm. in diameter; submersed leaves 1.5–4 cm. wide, mostly 3–5 times as long as wide, sessile or petiolate, nerves mostly 9–17; floating leaves 4–13 cm. long, 2–6.5 cm. wide, petioles mostly shorter than the blades; stipules (1–) 2.5–8 cm. long, (.3–) .5–1.2 mm. wide, keels prominent; peduncles not clavate; fruiting spikes (2.5–) 3–6 cm. long, .8–1 cm. thick; sepaloid connectives mostly 1.6–3 mm. wide; fruits (2.5–) 2.7–3.5 cm. long, (2.1–) 2.2–3 cm. wide; stele with the pattern various in type; interlacunar bundles in the outer interlacunar circle or sometimes also in the other interlacunar circles . . . . 10. *P. illinoensis.*

5. Submersed leaves narrowly linear, less than 3 mm.

wide and more than 50 times as long as broad, nerves 1–5; stele of the trio-type pattern with 2 patches of phloem on the inner face of the trio-bundle (subsect. NATANTES)....10.

10. Stem .8–2 mm. in diameter; submersed leaves .8–2 mm. wide; floating leaf-blades 4–9 cm. long, 2.5–6 cm. wide, usually cordate at base, on petioles 1–2.5 mm. thick; stipules 4.5–11 cm. long, strongly keeled; peduncles as thick as the stem; sepaloid connectives mostly 1.8–2.2 mm. wide; fruiting spikes .9–1.2 cm. thick; mature fruits mostly 3.5–5 mm. long, 2.5–3.5 mm. wide, keels scarcely developed, endocarp usually pitted on the sides, apex of seed pointing toward the basal end; stele with 3–5 lateral bundles on each side; interlacunar bundles strongly developed in more than 1 interlacunar circle; pseudo-hypodermis present; epidermal cells 1.5–3 (–4) times as long as broad..........7. *P. natans.*

10. Stem .5–1 mm. in diameter; submersed leaves .25–1 mm. wide; floating leaf-blades 1.5–5.5 cm. long, 1–3 cm. wide, rounded or cuneate at base, on petioles .2–1 mm. thick; stipules 1–5.5 cm. long, keels prominent only at base; peduncles thicker than the stem; sepaloid connectives mostly 1.3–1.8 mm. wide; fruiting spikes .7–.9 cm. thick; mature fruits mostly 2.5–3.5 mm. long, 2–2.4 mm. wide, keels prominent, endocarp sometimes depressed on the sides but not pitted, apex of seed pointing a little above the basal end; stele with 2–3 lateral bundles on each side; interlacunar bundles strongly developed in but 1 interlacunar circle; pseudo-hypodermis usually absent; epidermal cells 4–7 times as long as broad 8. *P. Oakesianus.*

2. Leaves all submersed, cordate or rounded at base, clasping ½ to ¾ the circumference of the stem....11.

11. Rhizomes spotted with rusty red; leaves ovate-oblong (5–) 10–20 (–25) cm. long, apex often cucullate, margins entire; stipules usually persistent and conspicuous; peduncles (5–) 15–60 cm. long; fruits more than 4 mm. long and more than 3 mm. wide, dorsal keel strongly developed; stele with the proto-type pattern; endodermis of U-cells; interlacunar and subepidermal bundles present (subsect. PRAELONGI)..........11. *P. praelongus.*

11. Rhizomes unspotted; leaves orbicular to ovate-lanceolate, seldom ovate-oblong, 1–10 cm. long, apex not cucullate, margin with fugacious, translucent, one-celled denticles; stipules usually inconspicuous or disintegrated to fibers; peduncles 1–25 cm. long; fruits less than 3.5 mm. long and less than 3 mm. wide, dorsal keel weakly developed, or none; stele with the trio-type pattern; endodermis of O-cells; interlacunar and subepidermal bundles absent (subsect. PERFOLIATI)....12.

12. Leaves ovate-lanceolate to narrowly lanceolate, 3–10 cm. long, coarsely nerved; stipules coarse, disinte-

grating to persistent whitish fibers; peduncles often clavate, 1.5–25 cm. long; fruiting spikes about 1 cm. thick; fruits (2.5–) 2.7–3.2 (–3.5) mm. long, (2–) 2.3–2.6 (–3) mm. wide; endocarp-loop with a cavity......,..........................12. *P. Richardsonii.*

12. Leaves orbicular to ovate-lanceolate, the principal ones 1–6 cm. long, delicately nerved; stipules delicate, fugacious; peduncles never clavate, 1–9 cm. long; fruiting spikes about .8 cm. thick; fruits (2.3–) 2.5–2.7 (–3) mm. long, (1.7–) 2–2.1 (–2.3) mm. wide; endocarp-loop solid..................13. *P. perfoliatus.*

Key to the Species Based on the Anatomy of the Stem

1. Interlacunar bundles present....2.
  2. Interlacunar bundles strongly developed throughout....3.
    3. Stele of the proto-type pattern....4.
      4. Endodermis of O-cells; subepidermal bundles absent 4. *P. amplifolius.*
      4. Endodermis of U-cells; subepidermal bundles present 11. *P. praelongus.*
    3. Stele of the trio-type pattern, with the phloem on the inner face of the trio-bundle appearing as 2 distinct patches; endodermis of U-cells; subepidermal bundles present..7. *P. natans.*
  2. Interlacunar bundles strongly developed only in the outer interlacunar circle (if present in other interlacunar circles, then few or weakly developed); endodermis of U-cells....5.
    5. Stele of the trio-type or proto-type pattern....6.
      6. Stele of the trio-type pattern with the phloem on the inner face of the trio-bundle appearing as 2 distinct patches; epidermal cells 4–7 times as long as broad 8. *P. Oakesianus.*
      6. Stele various in pattern; epidermal cells 1–4 times as long as broad.............................10. *P. illinoensis.*
    5. Stele of the oblong-type pattern....7.
      7. Stele with 1 (rarely with 2) central bundle and usually but 1 lateral bundle on each side; interlacunar bundles only in the outer interlacunar circle; stem .5–1 mm. in diameter..........................9. *P. gramineus.*
      7. Stele with 2 (rarely with 1) central bundles and 2 or 3 lateral bundles on each side; interlacunar bundles in the outer interlacunar circle and sometimes also in the other interlacunar circles; stem (1–) 1.5–2.5 mm. in diameter........................10. *P. illinoensis.*
1. Interlacunar bundles absent; endodermis of O-cells (rarely with a few U-cells)....8.
  8. Stele of the oblong-type pattern; stem laterally compressed..1. *P. crispus.*
  8. Stele of the trio-type or proto-type pattern; stem terete....9.
    9. Stele with the proto-type pattern....10.
      10. Subepidermal bundles present.............3. *P. polygonifolius.*
      10. Subepidermal bundles absent...................5. *P. pulcher.*
    9. Stele with the trio-type pattern....11.
      11. Stele with the phloem on the inner face of the trio-bundle appearing as 1 patch; pseudo-hypodermis absent.....................................6. *P. nodosus.*

11. Stele with the phloem on the inner face of the trio-bundle appearing as 2 patches (rarely with but 1)....12.
    12. Pseudo-hypodermis present..............12. *P. Richardsonii* and 13. *P. perfoliatus.*
    12. Pseudo-hypodermis absent....................2. *P. alpinus.*

Selective Key to the Subsections

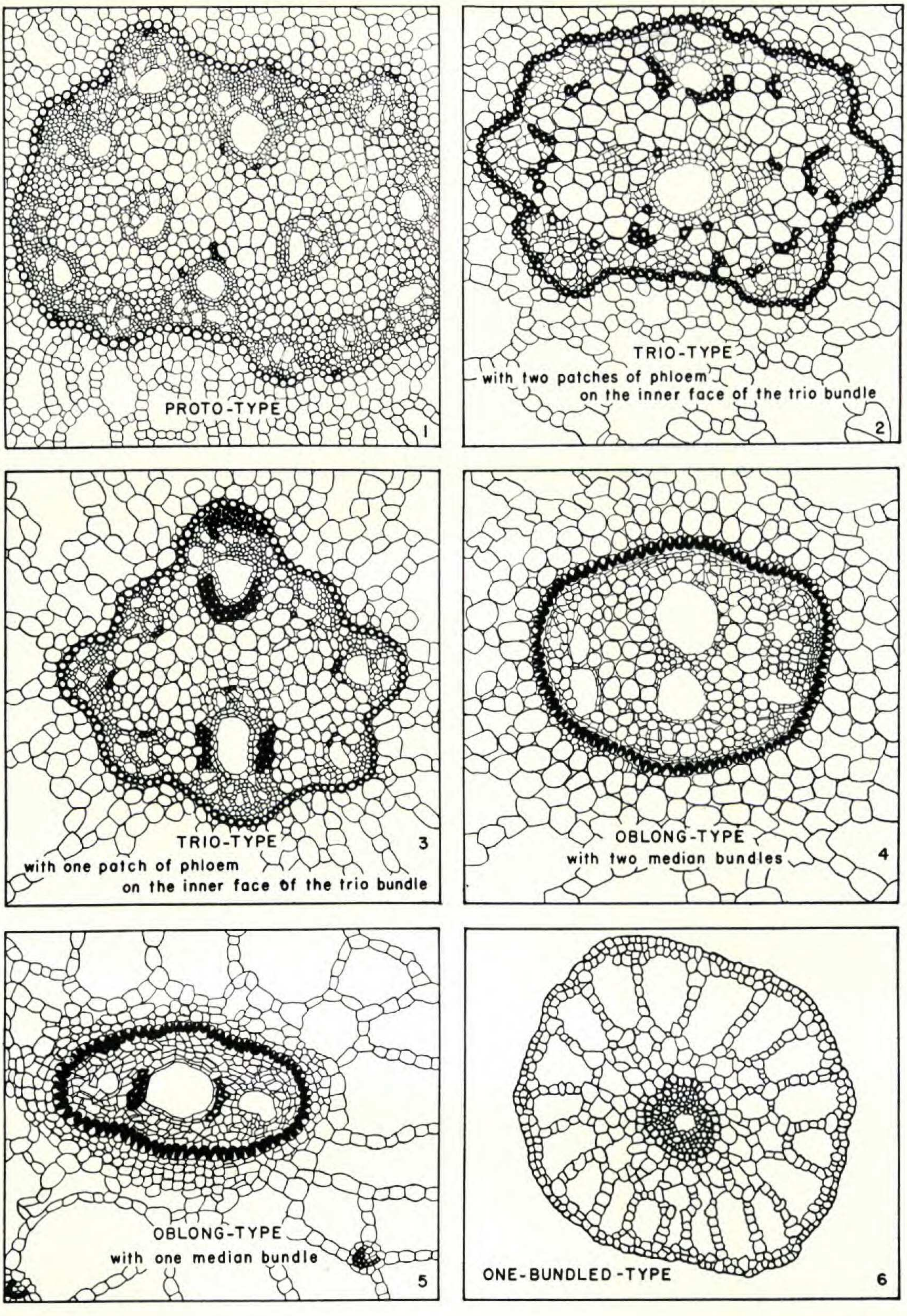
The following key is offered as a practical one for determining the subsection to which a specimen belongs. It is based on characters available with sterile and otherwise incomplete specimens. It is selective in that the user may choose the order in which the characters may be applied. This is of decided advantage when certain parts of the specimen are absent or difficult to make out, for the other parts may be sufficient for determining the subsection.

The key is extremely easy to use. Any character may be selected which, if not sufficient to name the subsection, will lead to a number. This number will be found heading a column on one of the following pages. On this page another character is now selected and opposite it in the designated column may be found a symbol or new number. This is continued until a symbol appears, which will designate the proper subsection. At any time the subsections that are still possibilities may be ascertained by reference to page 86. If a specimen traces to zero (0) it may be suspected that a character has been selected incorrectly or the specimen is a hybrid with parents in more than one subsection. The subsection *Crispi* is omitted from this key for it is represented only by the introduced species *P. crispus*, which can easily be distinguished from all our indigenous species of *Potamogeton* by its definitely toothed leaf-margins.

When the subsection is determined, reference to the portion of the general key, on pages 72 to 75, dealing with that subsection should give the name of the species.

The following symbols are used to designate the subsections:

AL *Alpini*	AM *Amplifolii*	NA *Natantes*	PR *Praelongi*
CO *Colorati*	NO *Nodosi*	LU *Lucentes*	PE *Perfoliati*



CAMERA-LUCIDA DRAWINGS (cell-contents not shown) FROM STEMS OF POTAMOGETON SHOWING TYPES OF STELES.

STEM		
STELE		
Proto-type	CO AM LU PR	18
Trio-type	AL NO NA LU PE	8
Oblong-type		LU
ENDODERMIS		
O-cells	AL CO AM NO PE	11
U-cells	CO NA LU PR	17
INTERLACUNAR BUNDLES		
Present	AM NA LU PR	15
Absent	AL CO AM NO PE	11
SUBEPIDERMAL BUNDLES		
Present	CO NA LU PR	17
Absent	AL AM NO LU PE	10
SUBMERSED LEAVES		
SHAPE		
Orbicular	AM PE	66
Ovate	AM LU PR PE	13
Oblong	AL IL PR	48
Lanceolate	AL CO AM NO LU PR PE	2
Oblanceolate or elliptic	AL AM LU	55
Linear	NO NA LU	33
BASE		
Clasping	AL PR PE	46
Not clasping	AL CO AM NO NA LU	5
APEX		
Rounded	AL NA PR PE	20
Acutish	AL CO AM NO LU PE	4
Sharp-pointed	AM NO LU	40
Mucronate	AM LU	68
PETIOLE		
Present	CO AM NO LU	19
Absent	AL AM NA LU PR PE	3
MARGIN		
Entire	AL CO AM NO NA LU PR PE	1
Denticulate	NO LU PE	32
NERVES		
1–5	AL NO NA LU PE	8
6–11	AL CO AM NO LU PE	4
12–21	AM NO LU PR PE	6
22–	AM PR PE	34
STIPULES		
Intact and well developed	AL CO AM NO NA LU PR PE.	1
Disintegrated to fibers	AM NA PR PE	14
Delicate or fugacious	AL AM PR PE	24
FLOATING LEAVES		
BASE		
Cordate	CO AM NA	44
Rounded or cuneate	CO AM NO NA LU	7
Tapering		AL
NERVES		
1–10	AL NO NA	53
11–23	AL CO AM NO NA LU	5
24–	AM NA LU	38

	1	2	3	4	5	6	7	8	9	10
STEM										
Stele										
Proto-type	18	18	36	43	43	36	43	LU	36	68
Trio-type	8	22	21	22	23	32	33	8	47	22
Oblong-type	LU	LU	LU	LU	LU	LU	LU	LU	LU	LU
Endodermis										
O-cells	11	11	54	78	29	39	45	51	54	27
U-cells	17	41	31	71	42	59	42	62	59	LU
Interlacunar B.										
Present	15	36	15	68	38	36	38	62	36	68
Absent	11	11	54	11	29	39	45	51	54	27
Subepidermal B.										
Present	17	41	31	71	42	59	42	62	59	LU
Absent	10	10	25	10	28	16	40	22	25	10
SUBMERSED LEAVES										
Shape										
Orbicular	66	66	66	66	AM	66	AM	PE	66	66
Ovate	13	13	13	35	68	13	68	58	13	35
Oblong	48	48	48	76	76	59	LU	76	48	76
Lanceolate	2	2	9	4	12	6	19	22	9	10
Oblanc. or ell.	55	55	55	55	55	68	68	76	55	55
Linear	33	64	62	64	33	64	33	33	LU	64
Base										
Clasping	46	46	46	74	AL	57	0	74	46	74
Not clasping	5	12	26	12	5	40	7	23	55	28
Apex										
Rounded	20	46	20	74	77	57	NA	49	46	74
Acutish	4	4	25	4	12	16	19	22	25	10
Sharp-pointed	40	40	68	40	40	40	40	64	68	40
Mucronate	68	68	68	68	68	68	68	LU	68	68
Petiole										
Present	19	19	68	19	19	40	19	64	68	40
Absent	3	9	3	25	26	13	38	21	9	25
Margin										
Entire	1	2	3	4	5	6	7	8	9	10
Denticulate	32	32	58	16	64	32	64	32	58	32
Nerves										
1–5	8	22	21	22	23	32	33	8	47	22
6–11	4	4	25	4	12	16	19	22	25	10
12–21	6	6	13	16	40	6	40	32	13	16
22–	34	34	34	66	AM	34	AM	PE	34	66
STIPULES										
Intact	1	2	3	4	5	6	7	8	9	10
Fibers	14	34	14	66	69	34	69	60	34	66
Del. or fug.	24	24	24	54	79	34	AM	74	24	54
FLOATING LEAVES										
Base										
Cordate	44	73	69	73	44	AM	44	NA	AM	AM
Round. or cun.	7	19	38	19	7	40	7	33	68	40
Tapering	AL	AL	AL	AL	AL	0	0	AL	AL	AL
Nerves										
1–10	53	78	77	78	53	NO	65	53	AL	78
11–23	5	12	26	12	5	40	7	23	55	28
24–	38	68	38	68	38	68	38	62	68	68

STEM	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*
STELE										
Proto-type	73	43	36	67	36	68	41	18	43	PR
Trio-type	51	52	58	60	62	32	62	LU	64	49
Oblong-type	0	LU	LU	0	LU	LU	LU	LU	LU	0
ENDODERMIS										
O-cells	11	29	66	66	AM	39	CO	73	45	74
U-cells	CO	71	59	61	31	LU	17	41	71	61
INTERLACUNAR B.										
Present	AM	68	36	37	15	68	31	36	68	61
Absent	11	29	66	66	AM	39	CO	73	45	74
SUBEPIDERMAL B.										
Present	CO	71	59	61	31	LU	17	41	71	61
Absent	27	28	35	66	68	16	LU	68	40	74
SUBMERSED LEAVES										
SHAPE										
Orbicular	66	AM	66	66	AM	66	0	AM	AM	PE
Ovate	66	68	13	34	36	35	59	36	68	57
Oblong	AL	76	59	PR	59	LU	59	59	LU	75
Lanceolate	11	12	13	34	36	16	41	18	19	46
Oblanc. or ell.	79	55	68	AM	68	68	LU	68	68	AL
Linear	NO	64	LU	NA	62	64	62	LU	64	NA
BASE										
Clasping	74	AL	57	57	PR	PE	PR	PR	0	46
Not clasping	29	12	68	69	38	40	42	43	19	77
APEX										
Rounded	74	AL	57	30	61	PE	61	PR	0	20
Acutish	11	12	35	66	68	16	71	43	19	74
Sharp-pointed	70	40	68	AM	68	40	LU	68	40	0
Mucronate	AM	68	68	AM	68	68	LU	68	68	0
PETIOLE										
Present	45	19	68	AM	68	40	71	43	19	0
Absent	54	55	13	14	15	35	31	36	68	20
MARGIN										
Entire	11	12	13	14	15	16	17	18	19	20
Denticulate	63	64	58	PE	LU	32	LU	LU	64	PE
NERVES										
1–5	51	52	58	60	62	32	62	LU	64	49
6–11	11	12	35	66	68	16	71	43	19	74
12–21	39	40	13	34	36	16	59	36	40	57
22–	66	AM	34	34	67	66	PR	67	AM	57
STIPULES										
Intact	11	12	13	14	15	16	17	18	19	20
Fibers	66	AM	34	14	37	66	61	67	AM	30
Del. or fug.	54	79	34	34	67	66	PR	67	AM	46
FLOATING LEAVES										
BASE										
Cordate	73	73	AM	69	69	AM	72	73	73	NA
Round. or cun.	45	19	68	69	38	40	42	43	19	NA
Tapering	AL	AL	0	0	0	0	0	0	0	AL
NERVES										
1–10	78	78	0	NA	NA	NO	NA	0	NO	77
11–23	29	12	68	69	38	40	42	43	19	77
24–	AM	68	68	69	38	68	62	68	68	NA

	21	22	23	24	25	26	27	28	29	30
STEM										
Stele										
Proto-type	LU	LU	LU	67	68	68	AM	68	73	PR
Trio-type	21	22	23	74	47	50	51	52	78	60
Oblong-type	LU	LU	LU	0	LU	LU	0	LU	0	0
Endodermis										
O-cells	74	51	78	54	54	79	27	56	29	PE
U-cells	62	LU	62	PR	LU	62	0	LU	CO	61
Interlacunar B.										
Present	62	LU	62	67	68	38	AM	68	AM	61
Absent	74	51	78	54	54	79	27	56	29	PE
Subepidermal B.										
Present	62	LU	62	PR	LU	62	0	LU	CO	61
Absent	47	22	52	54	93	55	27	28	56	PE
SUBMERSED LEAVES										
Shape										
Orbicular	PE	PE	0	66	66	AM	66	AM	AM	PE
Ovate	58	58	LU	34	35	68	66	68	AM	57
Oblong	76	76	76	75	76	76	AL	76	AL	PR
Lanceolate	47	22	52	24	25	55	27	28	29	57
Oblanc. or ell.	76	76	76	79	55	55	79	55	79	0
Linear	62	64	33	0	LU	62	NO	64	NO	NA
Base										
Clasping	74	74	AL	46	74	AL	74	AL	AL	57
Not clasping	50	52	23	79	55	26	56	28	29	NA
Apex										
Rounded	49	74	77	46	74	77	74	AL	AL	30
Acutish	47	22	52	54	25	55	27	28	29	PE
Sharp-pointed	LU	64	64	AM	68	68	70	40	70	0
Mucronate	LU	LU	LU	AM	68	68	AM	68	AM	0
Petiole										
Present	LU	64	64	AM	68	68	70	40	45	0
Absent	21	47	50	24	25	26	54	55	79	30
Margin										
Entire	21	22	23	24	25	26	27	28	29	30
Denticulate	58	32	64	PE	58	LU	63	64	NO	PE
Nerves										
1–5	21	22	23	74	47	50	51	52	78	60
6–11	47	22	52	54	25	55	27	28	29	PE
12–21	58	32	64	34	35	68	39	40	70	57
22–	PE	PE	0	34	66	AM	66	AM	AM	57
STIPULES										
Intact	21	22	23	24	25	26	27	28	29	30
Fibers	60	PE	NA	34	66	69	66	AM	AM	30
Del. or fug.	74	74	AL	24	54	79	54	79	79	57
FLOATING LEAVES										
Base										
Cordate	NA	0	NA	AM	AM	69	AM	AM	73	NA
Round. or cun.	62	64	33	AM	68	38	70	40	45	NA
Tapering	AL	AL	AL	AL	AL	AL	AL	AL	AL	0
Nerves										
1–10	77	78	53	AL	AL	77	78	78	78	NA
11–23	50	52	23	79	55	26	56	28	29	NA
24–	62	LU	62	AM	68	38	AM	68	AM	NA

STEM	*31*	*32*	*33*	*34*	*35*	*36*	*37*	*38*	*39*	*40*
Stele										
Proto-type	59	LU	LU	67	68	36	67	68	AM	68
Trio-type	62	32	33	PE	58	LU	NA	62	63	64
Oblong-type	LU	LU	LU	0	LU	LU	0	LU	0	LU
Endodermis										
O-cells	0	63	NO	66	66	AM	AM	AM	39	70
U-cells	31	LU	62	PR	LU	59	61	62	0	LU
Interlacunar B.										
Present	31	LU	62	67	68	36	37	38	AM	68
Absent	0	63	NO	66	66	AM	AM	AM	39	70
Subepidermal B.										
Present	31	LU	62	PR	LU	59	61	62	0	LU
Absent	LU	32	64	66	35	68	AM	68	39	40
SUBMERSED LEAVES										
Shape										
Orbicular	0	PE	0	66	66	AM	AM	AM	66	AM
Ovate	59	58	LU	34	35	36	67	68	66	68
Oblong	59	LU	LU	PR	LU	59	PR	LU	0	LU
Lanceolate	59	32	64	34	35	36	67	68	39	40
Oblanc. or ell	LU	LU	LU	AM	68	68	AM	68	AM	68
Linear	62	64	33	0	LU	LU	NA	62	NO	64
Base										
Clasping	PR	PE	0	57	PE	PR	PR	0	PE	0
Not clasping	62	64	33	AM	68	68	69	38	70	40
Apex										
Rounded	61	PE	NA	57	PE	PR	61	NA	PE	0
Acutish	LU	32	64	66	35	68	AM	68	39	40
Sharp-pointed	LU	64	64	AM	68	68	AM	68	70	40
Mucronate	LU	LU	LU	AM	68	68	AM	68	AM	68
Petiole										
Present	LU	64	64	AM	68	68	AM	68	70	40
Absent	31	58	62	34	35	36	37	38	66	68
Margin										
Entire	31	32	33	34	35	36	37	38	39	40
Denticulate	LU	32	64	PE	58	LU	0	LU	63	64
Nerves										
1–5	62	32	33	PE	58	LU	NA	62	63	64
6–11	LU	32	64	66	35	68	AM	68	39	40
12–21	59	32	64	34	35	36	67	68	39	40
22–	PR	PE	0	34	66	67	67	AM	66	AM
STIPULES										
Intact	31	32	33	34	35	36	37	38	39	40
Fibers	61	PE	NA	34	66	67	37	69	66	AM
Del. or fug	PR	PE	0	34	66	67	67	AM	66	AM
FLOATING LEAVES										
Base										
Cordate	NA	0	NA	AM	AM	AM	69	69	AM	AM
Round. or cun	62	64	33	AM	68	68	69	38	70	40
Tapering	0	0	0	0	0	0	0	0	0	0
Nerves										
1–10	NA	NO	65	0	0	0	NA	NA	NO	NO
11–23	62	64	33	AM	68	68	69	38	70	40
24–	62	LU	62	AM	68	68	69	38	AM	68

	41	*42*	*43*	*44*	*45*	*46*	*47*	*48*	*49*	*50*
STEM										
Stele										
Proto-type	41	71	43	73	73	PR	LU	59	0	LU
Trio-type	LU	62	LU	NA	NO	74	47	76	49	50
Oblong-type	LU	LU	LU	0	0	0	LU	LU	0	LU
Endodermis										
O-cells	CO	CO	73	73	45	74	74	AL	74	AL
U-cells	41	42	71	72	CO	PR	LU	59	NA	62
Interlacunar B.										
Present	59	62	68	69	AM	PR	LU	59	NA	62
Absent	CO	CO	73	73	45	74	74	AL	74	AL
Subepidermal B.										
Present	41	42	71	72	CO	PR	LU	59	NA	62
Absent	LU	LU	68	AM	70	74	47	76	74	76
SUBMERSED LEAVES										
Shape										
Orbicular	0	0	AM	AM	AM	PE	PE	0	PE	0
Ovate	59	LU	68	AM	AM	57	58	59	PE	LU
Oblong	59	LU	LU	0	0	75	76	48	AL	76
Lanceolate	41	71	43	73	45	46	47	48	74	76
Oblanc. or ell.	LU	LU	68	AM	AM	AL	76	76	AL	76
Linear	LU	62	LU	AM	NO	0	LU	LU	NA	62
Base										
Clasping	PR	0	0	0	0	46	74	75	74	AL
Not clasping	71	42	43	44	45	AL	76	76	77	50
Apex										
Rounded	PR	NA	0	NA	0	46	74	75	49	77
Acutish	71	71	43	73	45	74	47	76	74	76
Sharp-pointed	LU	LU	68	AM	70	0	LU	LU	0	LU
Mucronate	LU	LU	68	AM	AM	0	LU	LU	0	LU
Petiole										
Present	71	71	43	73	45	0	LU	LU	0	LU
Absent	59	62	68	69	AM	46	47	48	49	50
Margin										
Entire	41	42	43	44	45	46	47	48	49	50
Denticulate	LU	LU	LU	0	NO	PE	58	LU	PE	LU
Nerves										
1–5	LU	62	LU	NA	NO	74	47	76	49	50
6–11	71	71	43	73	45	74	47	76	74	76
12–21	59	LU	68	AM	70	57	58	59	PE	LU
22–	PR	0	AM	AM	AM	57	PE	PR	PE	0
STIPULES										
Intact	41	42	43	44	45	46	47	48	49	50
Fibers	PR	NA	AM	69	AM	57	PE	PR	60	NA
Del. or fug.	PR	0	AM	AM	AM	46	74	75	74	LU
FLOATING LEAVES										
Base										
Cordate	CO	72	73	14	73	0	0	0	NA	NA
Round. or cun.	41	42	43	44	45	0	LU	LU	NA	62
Tapering	0	0	0	0	0	AL	AL	AL	AL	AL
Nerves										
1–10	0	NA	0	NA	NO	AL	AL	AL	77	77
11–23	71	42	43	44	45	AL	76	76	77	50
24–	LU	62	68	69	AM	0	LU	LU	NA	62

STEM	*51*	*52*	*53*	*54*	*55*	*56*	*57*	*58*	*59*	*60*
STELE										
Proto-type	0	LU	0	AM	68	AM	PR	LU	59	0
Trio-type	51	52	53	74	76	78	PE	58	LU	60
Oblong-type	0	LU	0	0	LU	0	0	LU	LU	0
ENDODERMIS										
O-cells	51	78	78	54	79	56	PE	PE	0	PE
U-cells	0	LU	NA	0	LU	0	PR	LU	59	NA
INTERLACUNAR B.										
Present	0	LU	NA	AM	68	AM	PR	LU	59	NA
Absent	51	78	78	54	79	56	PE	PE	0	PE
SUBEPIDERMAL B.										
Present	0	LU	NA	0	LU	0	PR	LU	59	NA
Absent	51	52	78	54	55	56	PE	58	LU	PE
SUBMERSED LEAVES										
SHAPE										
Orbicular	PE	0	0	66	AM	AM	PE	PE	0	PE
Ovate	PE	LU	0	66	68	AM	57	58	59	PE
Oblong	AL	76	AL	AL	76	AL	PR	LU	59	0
Lanceolate	51	52	78	54	55	56	57	58	59	PE
Oblanc. or ell.	AL	76	AL	79	55	79	0	LU	LU	0
Linear	NO	64	65	0	LU	NO	0	LU	LU	NA
BASE										
Clasping	74	AL	AL	74	AL	AL	57	PE	PR	PE
Not clasping	78	52	53	79	55	56	0	LU	LU	NA
APEX										
Rounded	74	AL	77	74	AL	AL	57	PE	PR	60
Acutish	51	52	78	54	55	56	PE	58	LU	PE
Sharp-pointed	NO	64	NO	AM	68	70	0	LU	LU	0
Mucronate	0	LU	0	AM	68	AM	0	LU	LU	0
PETIOLE										
Present	NO	64	NO	AM	68	70	0	LU	LU	0
Absent	74	76	77	54	55	79	57	58	59	60
MARGIN										
Entire	51	52	53	54	55	56	57	58	59	60
Denticulate	63	64	NO	PE	LU	NO	PE	58	LU	PE
NERVES										
1–5	51	52	53	74	76	78	PE	58	LU	60
6–11	51	52	78	54	55	56	PE	58	LU	PE
12–21	63	64	NO	66	68	70	57	58	59	PE
22–	PE	0	0	66	AM	AM	57	PE	PR	PE
STIPULES										
Intact	51	52	53	54	55	56	57	58	59	60
Fibers	PE	0	NA	AM	AM	AM	57	PE	PR	60
Del. or fug.	74	AL	AL	54	79	79	57	PE	PR	PE
FLOATING LEAVES										
BASE										
Cordate	0	0	NA	66	AM	AM	0	0	0	NA
Round. or cun.	NO	64	65	AM	68	70	0	LU	LU	NA
Tapering	AL	AL	AL	AL	AL	AL	0	0	0	0
NERVES										
1–10	78	78	53	AL	AL	78	0	0	0	NA
11–23	78	52	53	79	55	56	0	LU	LU	NA
24–	0	LU	NA	AM	68	AM	0	LU	LU	NA

	61	62	63	64	65	66	67	68	69	70
STEM										
STELE										
Proto-type	PR	LU	0	LU	0	AM	67	68	AM	AM
Trio-type	NA	62	63	64	65	PE	0	LU	NA	NO
Oblong-type	0	LU	0	LU	0	0	0	LU	0	0
ENDODERMIS										
O-cells	0	0	63	NO	NO	66	AM	AM	AM	70
U-cells	61	62	0	LU	NA	0	PR	LU	NA	0
INTERLACUNAR B.										
Present	61	62	0	LU	NA	AM	67	68	69	AM
Absent	0	0	63	NO	NO	66	AM	AM	AM	70
SUBEPIDERMAL B.										
Present	61	61	0	LU	NA	0	PR	LU	NA	0
Absent	0	LU	63	64	NO	66	AM	68	AM	70
SUBMERSED LEAVES										
SHAPE										
Orbicular	0	0	PE	0	0	66	AM	AM	AM	AM
Ovate	PR	LU	PE	LU	0	66	67	68	AM	AM
Oblong	PR	LU	0	LU	0	0	PR	LU	0	0
Lanceolate	PR	LU	63	64	NO	66	67	68	AM	70
Oblanc. or ell.	0	LU	0	LU	0	AM	AM	68	AM	AM
Linear	NA	62	NO	64	65	0	0	LU	NA	NO
BASE										
Clasping	PR	0	PE	0	0	PE	PR	0	0	0
Not clasping	NA	62	NO	64	65	AM	AM	68	69	70
APEX										
Rounded	61	NA	PE	0	NA	PE	PR	0	NA	0
Acutish	0	LU	63	64	NO	66	AM	68	AM	70
Sharp-pointed	0	LU	NO	64	NO	AM	AM	68	AM	70
Mucronate	0	LU	0	LU	0	AM	AM	68	AM	AM
PETIOLE										
Present	0	LU	NO	64	NO	AM	AM	68	AM	70
Absent	61	62	PE	LU	NA	66	67	68	69	AM
MARGIN										
Entire	61	62	63	64	65	66	67	68	69	70
Denticulate	0	LU	63	64	NO	PE	0	LU	0	NO
NERVES										
1–5	NA	62	63	64	65	PE	0	LU	NA	NO
6–11	0	LU	63	64	NO	66	AM	68	AM	70
12–21	PR	LU	63	64	NO	66	67	68	AM	70
22–	PR	0	PE	0	0	66	67	AM	AM	AM
STIPULES										
Intact	61	62	63	64	65	66	67	68	69	70
Fibers	61	NA	PE	0	NA	66	67	AM	69	AM
Del. or fug	PR	0	PE	0	0	66	67	AM	AM	AM
FLOATING LEAVES										
BASE										
Cordate	NA	NA	0	0	NA	AM	AM	AM	69	AM
Round. or cun	NA	62	NO	64	65	AM	AM	68	69	70
Tapering	0	0	0	0	0	0	0	0	0	0
NERVES										
1–10	NA	NA	NO	NO	65	0	0	0	NA	NO
11–23	NA	62	NO	64	65	AM	AM	68	69	70
24–	NA	62	0	LU	NA	AM	AM	68	69	AM

	71	72	73	74	75	76	77	78	79
STEM									
STELE									
Proto-type	71	CO	73	0	PR	LU	0	0	AM
Trio-type	LU	NA	0	74	AL	76	77	78	AL
Oblong-type	LU	0	0	0	0	LU	0	0	0
ENDODERMIS									
O-cells	CO	CO	73	74	AL	AL	AL	78	79
U-cells	71	72	CO	0	PR	LU	NA	0	0
INTERLACUNAR B.									
Present	LU	NA	AM	0	PR	LU	NA	0	AM
Absent	CO	CO	73	74	AL	AL	AL	78	79
SUBEPIDERMAL B.									
Present	71	72	CO	0	PR	LU	NA	0	0
Absent	LU	0	AM	74	AL	76	AL	78	79
SUBMERSED LEAVES									
SHAPE									
Orbicular	0	0	AM	PE	0	0	0	0	AM
Ovate	LU	0	AM	PE	PR	LU	0	0	AM
Oblong	LU	0	0	AL	75	76	AL	AL	AL
Lanceolate	71	CO	73	74	75	76	AL	78	79
Oblanc. or ell.	LU	0	AM	AL	AL	76	AL	AL	79
Linear	LU	NA	0	0	0	LU	NA	NO	0
BASE									
Clasping	0	0	0	74	75	AL	AL	AL	AL
Not clasping	71	72	73	AL	AL	76	77	78	79
APEX									
Rounded	0	NA	0	74	75	AL	77	AL	AL
Acutish	71	CO	73	74	AL	76	AL	78	79
Sharp-pointed	LU	0	AM	0	0	LU	0	NO	AM
Mucronate	LU	0	AM	0	0	LU	0	0	AM
PETIOLE									
Present	71	CO	73	0	0	LU	0	NO	AM
Absent	LU	NA	AM	74	75	76	77	AL	79
MARGIN									
Entire	71	72	73	74	75	76	77	78	79
Denticulate	LU	0	0	PE	0	LU	0	NO	0
NERVES									
1–5	LU	NA	0	74	AL	76	77	78	AL
6–11	71	CO	73	74	AL	76	AL	78	79
12–21	LU	0	AM	PE	PR	LU	0	NO	AM
22–	0	0	AM	PE	PR	0	0	0	AM
STIPULES									
Intact	71	72	73	74	75	76	77	78	79
Fibers	0	NA	AM	PE	PR	0	NA	0	AM
Del. or fug.	0	0	AM	74	75	AL	AL	AL	79
FLOATING LEAVES									
BASE									
Cordate	CO	72	73	0	0	0	NA	0	AM
Round. or cun.	71	72	73	0	0	LU	NA	NO	AM
Tapering	0	0	0	AL	AL	AL	AL	AL	AL
NERVES									
1–10	0	NA	0	AL	AL	AL	77	78	AL
11–23	71	72	73	AL	AL	76	77	78	79
24–	LU	NA	AM	0	0	LU	NA	0	AM

The numbers used in the selective key and the subsections they represent are as follows:

1. AL CO AM NO NA LU PR PE
2. AL CO AM NO LU PR PE
3. AL AM NA LU PR PE
4. AL CO AM NO LU PE
5. AL CO AM NO NA LU
6. AM NO LU PR PE
7. CO AM NO NA LU
8. AL NO NA LU PE
9. AL AM LU PR PE
10. AL AM NO LU PE
11. AL CO AM NO PE
12. AL CO AM NO LU
13. AM LU PR PE
14. AM NA PR PE
15. AM NA LU PR
16. AM NO LU PE
17. CO NA LU PR
18. CO AM LU PR
19. CO AM NO LU
20. AL NA PR PE
21. AL NA LU PE
22. AL NO LU PE
23. AL NO NA LU
24. AL AM PR PE
25. AL AM LU PE
26. AL AM NA LU
27. AL AM NO PE
28. AL AM NO LU
29. AL CO AM NO
30. NA PR PE
31. NA LU PR
32. NO LU PE
33. NO NA LU
34. AM PR PE
35. AM LU PE
36. AM LU PR
37. AM NA PR
38. AM NA LU
39. AM NO PE
40. AM NO LU
41. CO LU PR
42. CO NA LU
43. CO AM LU
44. CO AM NA
45. CO AM NO
46. AL PR PE
47. AL LU PE
48. AL LU PR
49. AL NA PE
50. AL NA LU
51. AL NO PE
52. AL NO LU
53. AL NO NA
54. AL AM PE
55. AL AM LU
56. AL AM NO
57. PR PE
58. LU PE
59. LU PR
60. NA PE
61. NA PR
62. NA LU
63. NO PE
64. NO LU
65. NO NA
66. AM PE
67. AM PR
68. AM LU
69. AM NA
70. AM NO
71. CO LU
72. CO NA
73. CO AM
74. AL PE
75. AL PR
76. AL LU
77. AL NA
78. AL NO
79. AL AM

SYNOPSIS OF SPECIES

1. P. CRISPUS Linnaeus

RHIZOME about same thickness as stem, buff or reddish, unspotted. STEM laterally compressed, simple or branched, .5–2 (2.5) mm. in greatest diameter; stele of the oblong-type pattern with but 1 central bundle and 1 lateral bundle on each side; endodermis of O-cells; interlacunar bundles absent; subepidermal bundles absent; pseudo-hypodermis 1 cell thick. LEAVES all submersed, linear-oblong to linear-oblanceolate, principal ones (3–) 5–8 (–10) cm. long, (.2–) .5–.8 (–1) cm. wide, semi-clasping at base, broadly rounded at apex; nerves 3–7; lacunae of 1 or 2 rows along the midrib; margins finely and irregularly dentate. STIPULES .5–1 cm. long, slightly adnate at base, upper part fraying early, leaving the papery or shreddy bases. PEDUNCLES terete, about same thickness as greatest diameter of stem, 2–5 (–7) cm. long. SPIKES in anthesis compact or moniliform, of 3–5 whorls of flowers; in fruit 1–2 cm. long, 1–1.3 cm. thick. Flowers sessile or on pedicels up to .4 mm. long; sepaloid connectives orbicular, (1.2–) 1.5–1.9 (–2.1) mm. wide, claws .3–.9 mm. long; anthers .7–1.1 (–1.3) mm. long. FRUITS ovate, (2–) 2.5–3 (–3.6) mm. long (excluding beak), (1.6–) 2–2.5 (–2.8) mm. wide; keels obtuse but prominent, dorsal one strongly developed below and with a small projecting tooth near the base; beak prominent, straight or incurved, 2–3 mm. long; exocarp rather smooth, greenish or brownish; endocarp loop solid and near the base; apex of seed pointing toward the basal end. WINTER BUDS hard and horny, 1–2 cm. thick.

P. crispus L., Sp. Pl. **1:** 126 (1753); C. & S., Linnaea **2:** 186 (1827); Morong, Mem. Torr. Club **3:** no. 2: 36 (1893); Graebn. in Engler, Pflanzenr. **4:** fam. 11: 97 (1907); Taylor, N. Am. Fl. **17:** pt. 1: 21 (1909); Hagstr., Crit. Res. Pot. 58 (1916).

Ponds and streams. Southern Quebec to Virginia, west to Missouri, also in California. MAP 1. Europe, Asia, Africa, Australia. The following are representative: QUEBEC: Ile Sainte-Therèse, St.-Jean Co., *Victorin & Rolland 45189* and *49141*. VERMONT: tributary of Lake Champlain, Charlotte, July 8–11, 1911, *Dutton;* Charlotte, Chittenden Co., July 7, 1911, *Kent* (N, mixed with *P. Richardsonii*). MASSACHUSETTS: Spy P., Arlington, Middlesex Co., Sept. 21, 1880, herb. *C. E. Faxon;* near Fresh Pond, Cambridge, Middlesex Co., *Fernald & Weatherby, Plantae Exsiccatae Grayanae 111;* Cambridge Bot. Gard., 1864, *J. T. Rothrock;* Sudbury R., Concord, Middlesex Co., *Ogden 1502*. CONNECTICUT: Housatonic R., Derby, *E. H. Eames 11502;* Lake Zoar, Housatonic R., Southbury, New Haven Co., *E. H. Eames 11485*. NEW YORK: Lake Ontario, southwest of Chaumont, Jefferson Co., *Fernald, Wiegand & Eames 14089;* Pierrepont P., Woodville, Jefferson Co., *House 10069;* north end of Cossayuna L., Washington Co., *Muenscher & Lindsey 2739;* abandoned canal, Montezuma, Cayuga Co., *Eames & Wiegand 14535;* pool at Eldridge L., Chemung Co., upper waters of the Susquehanna, *Lucy 10814;* Renwick Flats, Ithaca, Tompkins Co., *Wiegand 11182;* Old Ice Pond, Ithaca, *R. Jones 7471;* Float Bridge, Rochester, *Baxter 5388;* Lake Washington Park, Albany, Albany Co., June 14, 1910, *S. H. Burnham*. NEW JERSEY: tide ditches, Camden, May 5, 1866, *C. F. Parker;* Camden, June 1879, *I. C. Martindale;* Clifton, *Nash 786;* Cedar Brook, Plainfield, May 1879, *Frank Tweedy*. PENNSYLVANIA: Conestoga, near Lancaster, June 19, 1861, *T. C. Porter;* Juaniata R., Huntingdon

Co., Aug. 1864, *T. C. Porter;* Lehigh R., Easton, July 11, 1868, *T. C. Porter;* Sharon, July 7, 1886, *F. T. Aschman;* outlet of pond on tributary to Pennypack Creek, Willow Grove, Montgomery Co., *Adams & Tash 512.* DELAWARE: Wilmington, 1863, *Wm. M. Canby;* Wilmington, June 1879, *A. Commons;* Wooddale, June 24, 1879, *A. Commons;* Faulkland, New Castle Co., June 1879, *A. Commons;* Greenbank, Oct. 16, 1879, *A. Commons.* MARYLAND: Spesutie Island, May 27, 1879, *J. D. Smith;* Cleft Island, Great Falls, *McAtee 2953.* DISTRICT OF COLUMBIA: Fish Ponds, *Shull 15;* Georgetown, *VanEseltine & Moseley 201.* WEST VIRGINIA: Fish Hatchery, White Sulphur Springs, Greenbrier Co., *Berkley 1215.* VIRGINIA: Fourmile Run, Chesapeake Bay Region, *Shull 465;* near Four-mile Run, near Alexandria, *Blake 9472;* 1 mile s. w. of Williamsburg, *Grimes 3255;* Dyke, Fairfax Co., *Metcalf & Sperry 1631;* Claremont Wharf, Surrey Co., *Fernald & Long 7747.* ONTARIO: Toronto, *Scott 16439;* pool above Niagara Falls, *John Macoun 26830;* Kingston, June 15, 1901, *J. Fowler;* Sault Sainte Marie, Algoma Co., *Fassett 14746.* MICHIGAN: Muskegon Lake, Muskegon State Park, 4½ mi. w. of Muskegon, Muskegon Co., *Hermann 8647;* Kalamazoo R., Kalamazoo Co., Aug. 15, 1938, *W. G. Erwin.* Reported from Ottawa Co., and Van Buren Co. by Oosting.[1] INDIANA: Wolf L., June 7, 1913, *E. D. Hull;* east side of Wolf Lake, just w. of Whiting, Lake Co., *Deam 56607.* ILLINOIS: Wolf L., Chicago, June 10, 1911, *E. E. Sherff;* Stony Island, Chicago, Cook Co., *Steyermark 4227;* Lake Nippersink, according to Tehon, Torreya **29:** 42 (1929), specimen not seen. MINNESOTA: Lake Minnetonka, *Keck & Stilwill 428* and *430;* Mississippi R., Wabasha Co., *Keck & Stevens 335;* Mississippi bottoms, below Winona, Aug. 6, 1931, *H. J. Oosting.* MISSOURI: Neosho, *Metcalf 948;* Blue Spring L. and Osage L., formed by Blue Springs, 2 mi. s. e. of Bourbon, Crawford Co., *Steyermark 16313.* SOUTH DAKOTA: Edmunds Co., July 1896, *D. Griffiths* (specimen in Herb. Brooklyn Bot. Gard., not seen; see Torreya **29:** 43 (1929)). WYOMING: Lakes Swastika and Irene, Medicine Bow mountains (specimens not seen; see Torreya **32:** 5 (1932)). CALIFORNIA: cultivated at Pomona College, the plants brought from Santa Ana R., near Corona, "only known station in California," San Bernardino Co., *Parish 19248;* pond in botany lathhouse of Pomona College, planted by Johnston from Santa Ana R., *Munz 2785.* OREGON: near Silvies, Aug. 19, 1901, *Griffiths & Morris* (specimen in Herb. Brooklyn Bot. Gard., not seen; see Torreya **29:** 43 (1929)).

P. crispus is distinct from all other species of *Potamogeton* found in North America, and should never be confused with any

[1] Henry J. Oosting, Pap. Mich. Acad. Sci., Arts and Letters **15:** 165 (1932).

of them, for it is the only one with leaf-margins having a dentation evident to the unaided eye. Its fruits are distinctive in having long (2–3 mm.) beaks. Fruits are usually not produced when the plant grows in deep water, but in shallow, warm pools it fruits freely. The winter-buds are especially distinctive, being large (1–2 cm. thick) and hard and horny. This species is not native to the Western Hemisphere but is introduced into North America where in some places it is growing profusely and acting as a weed. It evidently arrived here rather early for Pursh in 1814 reports it from "Canada to Virginia."[1] Bennett says, "The oldest dated American specimen I can find in England is in Mr. Cosmo Melvill's herbarium, 'Philadelphia, 1841–2, Gavin Watson & Kilvington.' One from Delaware in the British Museum Herbarium is probably older: it was collected by R. Eglesfeld Griffith of Philadelphia . . . "[2] In 1913, Hull[3] reports it as being abundant and acting as a weed around Chicago in waters connected to Lake Michigan. He believed the arrival of the plant to that region to have been quite recent. Tehon[4] believes the westward spread of the species in North America to be due to migrating water birds and suggests that its introduction to North America may be due to the same agents.

2. P. ALPINUS Balbis (American varieties)

RHIZOME about same thickness as stem, branching and creeping, pinkish, not spotted. STEM terete, 1–2 mm. in diameter, simple below, rarely branched above, often pressing very flat; stele with the trio-type pattern, the phloem on the inner face of the trio-bundle usually appearing as two distinct patches; endodermis of O-cells; interlacunar and subepidermal bundles absent; pseudo-hypodermis absent. SUBMERSED LEAVES (excluding transition-leaves) thin, delicate, translucent, oblong-linear to linear-lanceolate, 4.5–18 cm. long, 1–2 cm. broad, usually with 7 prominent nerves, sometimes also having 2 to 6 less prominent or incomplete ones, sessile and slightly clasping, apex obtuse or rarely acutish but never sharp-pointed; margin entire; lacunae along the midrib of rectangular cells, 4–6 rows near the base, 2 or 3 rows at the middle and 0–2 rows near the apex. FLOATING LEAVES thin, translucent, often poorly developed or absent, blades elliptical or oblanceolate to obovate or oblong-linear,

[1] Frederick Pursh, Fl. Am. Sept. 120 (1814).
[2] Arthur Bennett, Journ. Bot. **39**: 201 (1901).
[3] E. D. Hull, RHODORA **15**: 171 (1913).
[4] L. R. Tehon, Torreya **29**: 42–46 (1929).

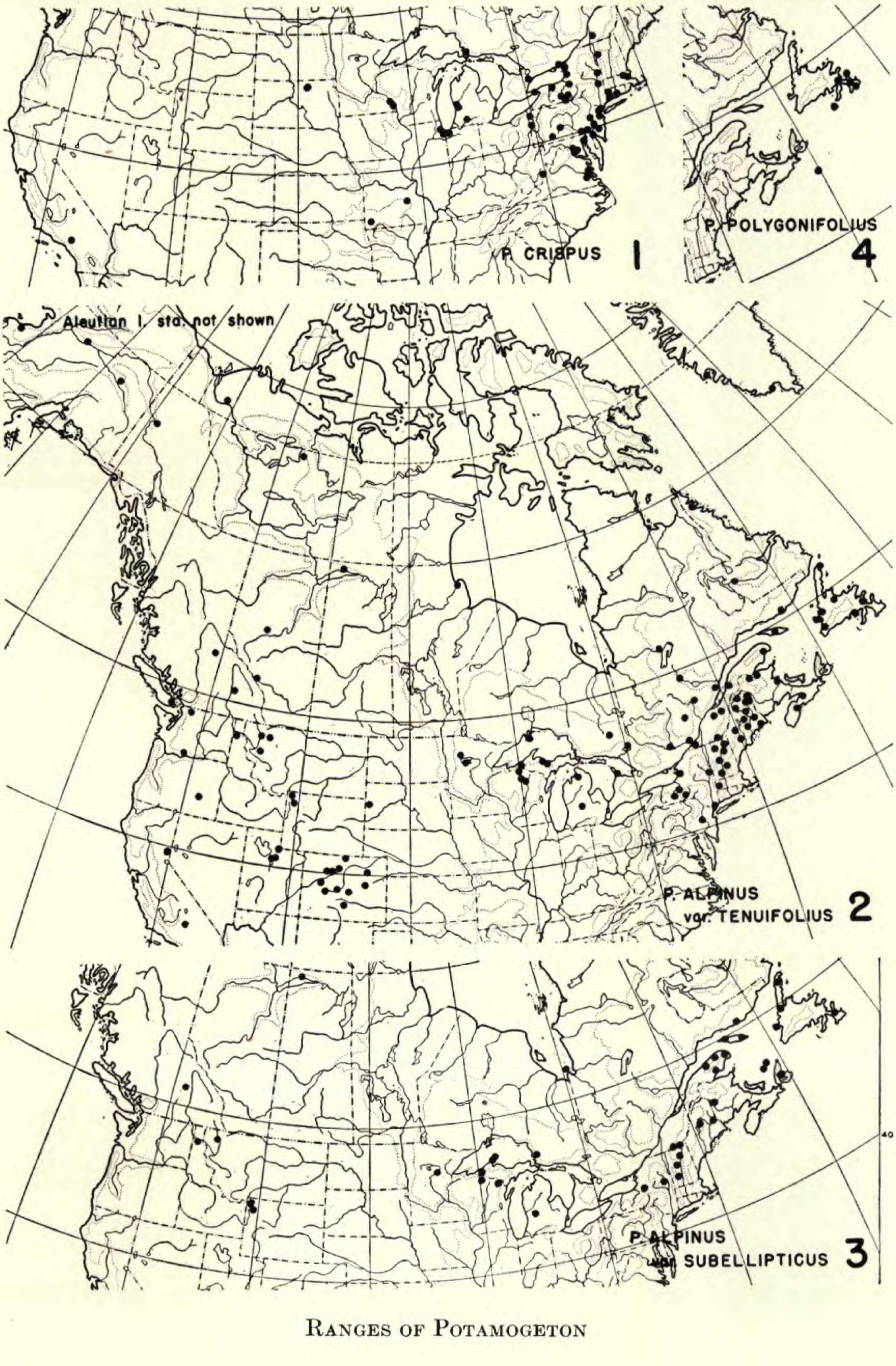
4–6.5 cm. long, 1–2 cm. wide, gradually tapering with no sharp distinction into a petiole 1–3 cm. long, with (7–) 9–13 (–15) prominent nerves, outer pair meeting the midrib a short distance back from the obtuse apex; lacunae along midrib of elongate cells near base and of oval cells near the middle, entire blade more or less lacunate with rounded lacunae. STIPULES of submersed leaves thin, membranous, oblong, obtuse, faintly 2-keeled with 3 lateral nerves on each side, which meet the keel-nerves back from the apex, (1.2–) 1.5–2.5 (–4) cm. long, 2–8 mm. broad; those of the transitional and floating leaves similar but broader (up to 1 cm.) and with more nerves (15), some also between the more prominent keel-nerves. PEDUNCLES same thickness as the stem, 3–10 (–16) cm. long. SPIKES in anthesis more or less moniliform, especially at the base, with 5–9 whorls of flowers; in fruit cylindric and crowded, 1.5–3.5 cm. long, .8–1 cm. thick. FLOWERS on short pedicels .5–1 mm. long; sepaloid connectives orbicular to reniform, blades 1.2–2 mm. wide, claws .7–.8 mm. long; anthers oblong, .6–1 mm. long. FRUITS mostly obovate, (2.5–) 3–3.5 mm. long (excluding beak), (1.7–) 2–2.4 mm. wide, lateral keels none or very low, dorsal keel thin, usually prominent and well developed upward, beak lateral, short and curved toward the back; exocarp smooth, pitted when immature, tawny-olive; endocarp with keels rounded, beak linear, 1–1.3 mm. long, curved toward the back, loop solid; apex of seed pointing toward basal end. Whole plant and especially the rachis of the spike usually suffused with red.

Two varieties in North America:

Submersed leaves oblong-linear to linear-lanceolate, 7–25 cm. long, usually more than 8 times as long as broad, tapering to an obtuse or acutish apex . . . . 2a. var. *tenuifolius*.
Submersed leaves oblong to ovate-oblong, 4–10 cm. long, usually less than 8 times as long as broad, apex rounded and sometimes slightly cucullate . . . . 2b. var. *subellipticus*.

2a. P. ALPINUS Balbis var. **tenuifolius** (Raf.), comb. nov.

P. tenuifolius Raf., Med. Repos. hex. 3, **2:** 409 (1811); Fernald, RHODORA **33:** 210 (1931). *P. lucens* sensu Michx. Fl. Bor.-Am. **1:** 101 (1803), in part, not L. (1753). *P. microstachys* Wolfg. in Schultes & Schultes, Mant. **3:** 360 (1827). *P. rufescens* "forma *angustifolia*" from Unalaska, C. & S., Linnaea **2:** 211 (1827). *P. obrutus* Wood, Cl.-Bk. ed. **2:** 525 (1847). *P. lucens* var.? *fluitans* (Roth) Gray, Man. ed. **2:** 435 (1856), as to synonyms *P. rufescens* Schrad. and *P. obrutus* Wood, not *P. fluitans* Roth. *P. alpinus* sensu Morong, Mem. Torr. Club **3:** no. 2: 19 (1893), in large part; sensu Graebn. in Engler, Pflanzenr. **4:** fam. 11: 70 (1907), as to Am. plant in large part; sensu Taylor, N. Am.



Ranges of Potamogeton

Fl. **17:** pt. 1: 19 (1909) in large part; sensu Hagstr., Crit. Res. Pot. 141 (1916), as to Am. plant, in large part. *P. alpinus* proles *microstachys* (Wolfg.) Graebn. in Engler, Pflanzenr. **4:** fam. 11: 72 (1907). *P. montanense* Gandog., Bull. Soc. Bot. France **66:** 304 (1920). *P. microstachys* var. *typicus* Fernald, Rhodora **32:** 80 (1930). *P. alpinus* subsp. *tenuifolius* (Raf.) Hultén, Fl. Aleut. Is. 65 (1937) and Fl. Alaska and Yukon 98 (1941). *P. rufescens* sensu Am. authors, in large part, not Schrad.

Streams and cold ponds, southwestern Greenland, Labrador, and Hudson Bay to Alaska and the Aleutian Islands, south to Newfoundland, Nova Scotia, western Massachusetts and Pennsylvania, Colorado and California. Map 2. The following, selected from many specimens, are representative: Greenland: Itivnera, 64° 22′ N., Godthaab Fjord, Aug. 19, 1931, *M. P. Porsild;* Qagssiarssuk, 60° 53′ N., Igaliko-Fjord, Aug. 5, 1925, *A. E. & M. P. Porsild;* Igaliko, July 23, 1888, *L. Kolderup Rosenvinge.* Labrador: Rama, *A. Stecker* 332; Seal L., n. Lab., *Spreadborough 16429;* Grand Falls of Hamilton R., *M. T. Doutt 3296.* Newfoundland: Little Quirpon, Quirpon Harbor, *Wiegand & Hotchkiss 27337;* Highlands Brook above pond, Crabbes, *R. B. Kennedy 81;* shores of Conception Bay, Carbonear, *Fernald & Wiegand 4473;* Grand Falls, Valley of Exploits River, *Fernald, Wiegand & Darlington 4474;* Lookout Mountain, West Arm (South Arm of charts), Bonne Bay, *Fernald, Long & Fogg 1207;* Grand L., Bay of Islands, *A. C. Waghorne 6;* St. Georges P., between Bay St. George and Bay of Islands, *Fernald & Wiegand 2443* (approaching var. *subellipticus*). Quebec: Natashquan, Saguenay Co., *St. John 90083 & 90084;* Lac Duguay, Newport, Gaspé Co., *Proulx 58;* Riv. Mistassin, (Michaux Herb., Paris Museum, as *P. lucens,* type of *P. tenuifolius* Raf., as to plant on right); Lac William, Mégantic Co., *Victorin 11162;* shallow lagoon, head of Sargents Bay, Lake Memphremagog, Aug. 3, 1903, *Churchill;* Bolton Center, Sherbrooke Co., *Pease 26709;* La Sarre, Abitibi, *Louis-Marie 313;* lac tourbeux, Ville Montel, Abitibi Region, *Victorin, Rolland & Meilleur 43730.* Anticosti: Anticosti I., *Victorin & Rolland 27630.* New Brunswick: Junction of Restigouche and Matapedia Rivers, *Rousseau 32332;* Bass R., Nepisiquit, July 30, 1873, *J. Fowler;* St. John R., Connors, *Pease 2907.* Nova Scotia: Truro, Colchester Co., *Bean & White 22963;* Mahone Bay, Hamilton *64010.* Maine: White's Brook, Seven Islands, T. 13, R. 14 & 15, valley of the St. John R., Aroostook Co., *St. John & Nichols 2104;* St. John R., Madawaska, *Fernald 117;* Piscataquis R., Dover, Aug. 27, 1894, *Fernald;* Mattagodus Stream, Tredwell School, Prentiss, Penobscot Co., *Steinmetz 323;* Haley Pond, Rangeley, Franklin Co., Sept. 1, 1894, *K. Furbish;* Pembroke, Washington Co., *Fernald 1622;* Sydney, Kennebec

Co., *Fernald & Long 12388*. New Hampshire: Colebrook, Coös Co., *Pease & Fernald 17024* (app. v. *subellipticus*); Horseshoe P., Northumberland, Coös Co., *Pease 17270* (app. v. *subellipticus*); Cherry P., Jefferson, Coös Co., July 1829, *J. W. Robbins;* bayou of the Connecticut R., Hanover, July 12, 1910, *E. F. Williams* (flaccid form). Vermont: Harvey's P., W. Barnet, Sept. 7, 1885, *F. Blanchard;* Windsor, Sept. 6, 1881, *Geo. Leland;* "e flumine Passumpsic," *A. Wood* (original collection of *P. obrutus*). Massachusetts: Richmond, Sept. 19, 1864, *Robbins*. New York: Preble, Cortland Co., July 31, 1886, *Dudley;* Paradox L., *Muenscher & Lindsey 2712;* Black R., Dexter, Jefferson Co., *Fernald, Wiegand & Eames 14082;* n. of R. R. bridge, Cayuga, Cayuga Co., Oct. 1886, *W. R. Dudley* (mixed with *P. illinoensis* in US); Oxford, June 30, 1886, *F. V. Coville*. Pennsylvania: near Easton, Aug. 4, 1869, *Thos. C. Porter*. Ontario: Cross L. Portage, Temagami Forest Reserve, *Krotkov 5142* (app. v. *subellipticus*); Current R., July 20, 1869, *John Macoun;* "Bruce Co., Peninsula," 1871, *John Macoun*. Michigan: Isle Royale, *W. S. Cooper*, no. "254 in part"; Dead R., Marquette, *C. F. Wheeler 26;* 3 mi. n. e. of Watersmeet, Gogebic Co., *Bessey B & D 2781;* Beaver R., Petoskey, July 2, 1878, *E. J. Hill;* Alma, Aug. 11, 1893, *C. A. Davis;* Chatham, *C. F. Wheeler 90*. Wisconsin: White Sand L., Vilas Co., Aug. 11, 1930, *J. P. E. Morrison;* Minocqua, Oneida Co., *Fassett 5343;* between McNaughton and Rhinelander on Wis. R., *L. S. Cheney 1501*. Manitoba: Churchill, *Polunin 1976, 1977, & 2062*. Minnesota: Lake Kilpatrick, Cass Co., Aug. 1893, *C. H. Bullard* (app. v. *subellipticus*); n. end of Squaw L., Clearwater Co., *Moyle 894* (app. v. *subellipticus*); South Dakota: Boulder Creek, Boulder Canyon, Lawrence Co., *Over 13817* (app. v. *subellipticus*). Mackenzie: Setidgi L., 68° 28′ N., 132° 20′ W., Aug. 21, *A. E. & R. T. Porsild;* McTavish Bay, Great Bear L., 66° 23′ N., 117° 40′ W., *A. E. & R. T. Porsild*. Saskatchewan: Cornwall Bay, L. Athabasca, 59° 27′ 30″ N., 108° 27′ 30″ W., *Raup 6618, 6621, & 6622*. Archibald R., vicinity of Wolverine Pt., L. Athabasca, 59° 9′ N., 108° 25′ W., *Raup 6741*. Alberta: Slave Lake Dist., *Brinkman 4541;* Vermillion Lakes, Banff, *Macoun 4365*. Montana: Medicine Lakes, *Maguire 472;* Swift Current Creek, *Maguire 474;* Trout Lake, *Maguire & Piranian 5442;* Rost L., Big Fork, *Whitford 258;* Swift Current Creek, below Lake McDermott, Glacier Nat'l Park, *Standley 16855;* Swan R. at Elbow (Lindberg) L., Mission Range, Missoula Co., *G. B. & R. P. Rossbach 16*. Idaho: Kootenai Co., Sept. 1887, *J. H. Sandberg*. Wyoming: Shoshone Lake, Yellowstone Nat'l Park, *Rydberg & Bessey 3724* (type no. of *P. montanense* Gandog.) & *3725;* Heart Lake Creek, Yellowstone region, Sept. 3, 1878, *C. Richardson* (mixed with v. *subel-*

lipticus in US). Colorado: Lake Eldora, Boulder Co., *Clokey 3118;* Georgetown, *M. E. Jones 734;* Walton Creek, Routt Co., July 1891, *A. Eastwood;* vicinity of Twin Lakes, July–Aug., 1902, *C. Juday;* Seven Lakes, *F. E. & E. S. Clements 491;* Grand Lake, *Shear & Bessey 5328;* Howe P. O., Larimer Co., *Osterhout 2885;* Tomichi R., Parlin, Gunnison Co., Aug. 20, 1901, *Benj. H. Smith.* Utah: Clayton Peak, Wasatch Mts., Aug. 12–26, 1903, *S. G. Stokes;* Twin Lakes, Alta, Wasatch Mts., *M. E. Jones 1297;* Silver L. at Brighton, Big Cottonwood Canyon, Salt Lake Co., *Maguire & Richards 13156;* Bridger L., Uinta Mts., Summit Co., *Rollins 2319;* Brighton, *M. E. Jones 6606.* California: North Fork of Kings R., *Hall & Chandler 563*, region of Kaweah Peaks, Funston's Meadows, Tulare Co., *Dudley 2201;* Webber L., Sierra Co., Aug. 3, 1894, *Dudley;* Silver Valley, Alpine Co., *Brewer 1978.* Oregon: in a warm spring, Harney Valley, June 10, 1885, *T. Howell* (mixed with *P. illinoensis*). Washington: Trout Creek, w. Klickitat Co., *Suksdorf 2172;* Falcon Valley, Mt. Adams, Sept. 1879, *Suksdorf;* Baker L., Whatcom Co., *Muenscher 7657a & 7658.* British Columbia: Kicking Horse L., Rocky Mts., Aug. 17, 1890, *John Macoun 4162;* Revelstoke, *John Macoun 4163;* Barkerville, *McCabe 43;* Nanaimo, Vancouver I., *John Macoun 4167 & 4167a.* Yukon: Bonanza Creek, *John Macoun 78320 & 78321.* Alaska: Goldstream Cr. and Pedro Dome, 65° 0′ N., 147° 30′ W., *A. E. & R. T. Porsild 114;* Buckland R., 65° 55′ N., 161° 0′ W., *A. E. & R. T. Porsild 1496;* Afognak L., Afognak Island, Shelikof Strait off Alaska Pen., Aug. 1931, *W. H. Rich;* Kodiak Island, *Trelease 2870 & 2871;* Shumagin Islands, *Saunders 2869;* False Pass, Unimak Island, Aleutian Islands, *Eyerdam 2141;* Unalaska (type-locality of *P. microstachys*), *Van Dyke 202*, also *Eyerdam 2360*, and *Hultén 7573;* Seldovia, *Piper 4426;* Kukak Bay, Alaska Pen., *Coville & Kearney 1564;* Olga Bay, Kodiak Island, *E. H. & H. B. Looff 1501.*

2b. P. alpinus Balbis var. **subellipticus** (Fernald), comb. nov.

P. microstachys var. *subellipticus* Fernald, Rhodora **32:** 82 (1930). *P. alpinus,* sensu Morong Mem. Torr. Club **3:** no. 2: 19 (1893), in small part; sensu Graebn., in Engler, Pflanzenr. **4:** fam. 11: 70 (1907), as to N. Am. plant in small part; sensu Taylor, N. Am. Fl. **17:** pt. 1: 19 (1909), in small part; sensu Hagstr., Crit. Res. Pot. 141 (1916), as to Am. plant in small part. *P. tenuifolius* var. *subellipticus* Fernald, Rhodora **33:** 211 (1931).

Shallow pools and slow streams, Newfoundland, south to southern Vermont and eastern New York, sparingly westward to Wyoming and Montana. Map. 3. The following are referred here: Newfoundland: Salmonier R., 1931, *Agnes Ayre;* Flower Cove, Straits of Belle Isle, *Fernald & Long 26221*, also *Hotchkiss*

27338; Stephenville, region of Bay St. George, *Fernald, Wiegand & Kittredge 2442;* Port à Port, *Mackenzie & Griscom 10047.* QUEBEC: Ile à la Proie, Archipel de Mingan, *Victorin & Rolland 20462;* Locked Camp, Rivière Cap Chat, Matane Co., *Victorin, Rolland & Jacques 44451;* Maria, Bonaventure Co., *Victorin, Rolland & Jacques 33315;* between Baldé and the Baie des Chaleurs, Bonaventure R., Bonaventure Co., *Collins, Fernald & Pease 5911;* Georgeville, *Pease 1919;* Charlton Island, about 52° N., 79° 30′ W., James Bay, *A. E. Porsild 4296;* Lac Philippe, Ladysmith, Pontiac Co., *Gauthier 2446.* ANTICOSTI: Rivière Sainte-Marie, *Victorin & Rolland 25938;* Rivière au Saumon, *Victorin, Rolland & Louis-Marie 20467.* MAGDALEN ISLANDS: East Cape and East Point, Coffin Island, *Fernald, Long & St. John 6766,* (TYPE in Gray Herb.); Ile de Havre-au-Ber, *Victorin & Rolland 9923.* NEW BRUNSWICK: Eel R., Dalhousie, *Svenson & Fassett 3028.* NOVA SCOTIA: Baddeck Bay, Victoria Co., *Fernald & Long 19687.* MAINE: Houlton, Aroostook Co., 1881, *K. Furbish,* also *Fernald & Long 12387;* Foxcroft, Piscataquis Co., Sept. 5, 1894, Sept. 15, 1894 & Aug. 31, 1896, *Fernald.* VERMONT: Little Leech Pond, Averill, Essex Co., *Eggleston 1656;* Willoughby, Orleans Co., Aug. 4 & 11, 1881, *E. Faxon;* "Nigger" P., Westmore, Orleans Co., *Eames & Godfrey 9334;* West Burke, *Redfield 8014;* Evart's P., Windsor, Aug. 27, 1933, *Weatherby & Griscom.* NEW YORK: Minerva Brook, east of Minerva, Essex Co., *House 15182;* Niagara Falls, Aug. 21, 1886, *Morong;* Paradox L., Essex Co., *Killip 12605* (mixed with *P. amplifolius* in US). ONTARIO: Howdenvale, *Watson 3144 & 3145;* River Trent, *John Macoun 4168;* Batchawana Falls, Algoma Dist., *Taylor et al. 294.* MICHIGAN: Eagle Harbor, Keweenaw Pen., 1863, *Robbins;* North Cliff, Keweenaw Co., Aug. 1, 1888, *O. A. Farwell;* west branch Ontonagon R., Tenderfoot L., Gogebic Co., *Hotchkiss & Koehler 4349.* WISCONSIN: Three Lakes, Oneida Co., Aug. 5, 1918, *R. Hoffman;* n. w. end of Big Arbor Vitae L., Vilas Co., *Hotchkiss & Martin 4460.* MINNESOTA: Lake Kilpatrick, Cass Co., Aug. 1893. *C. A. Ballard;* Gull L., Cass Co., Aug. 1893, *A. P. Anderson.* SASKATCHEWAN: Archibald R., vicinity of Wolverine Pt., L. Athabasca, about 59° 9′ N., 108° 25′ W., *Raup 6742.* MONTANA: Lake Josephine, Glacier Nat'l Park, *Maguire 473.* IDAHO: west end of Fernan L., Coeur d'Alene, *Rust 384.* WYOMING: Heart Lake Creek, Yellowstone region (mixed with v. *tenuifolius* in US; sheet in G not mixed); e. fork of Big Sandy, Wind River Mts., all 1878, *C. Richardson.* BRITISH COLUMBIA: Austey Creek, Shuswap L., *J. M. Macoun 4166.*

In 1930, Fernald showed that the American and eastern Asiatic plant which had been passing as *P. alpinus* Balbis of

Europe really differs from its European relative which has mostly broader submersed leaves with 9–15 nerves (as against 5–13 nerves in the American plant), a more compact inflorescence, and with the beak of the nutlet more or less straight so that the mature fruit is "narrowed and subequally attenuate to the prolonged submedian beak; those of the American and eastern Asiatic series broader, strongly rounded at the summit of the broad dorsal keel and laterally beaked at the summit of the ventral margin merely by a very short but often incurving style."[1] The submersed leaves of the wide-ranging American plant average narrower than those of typical *P. alpinus*, but broad-leaved plants occasionally occur and narrow-leaved ones are frequently found in Europe. Similarly, the degree of compactness of the spike is too variable to be more than a slightly supporting character. The differences in the shape of the fruit are, however, important. While foliage characters are rather variable among the broad-leaved species of *Potamogeton*, the characters of the fruit are more constant and any variation there is of primary importance. The fundamental difference between the fruits of the American and European plants lies in the rigidity of the beak of the endocarp. This beak is generally strong and rigid on the fruit of typical *P. alpinus* and remains rather straight at maturity. With the American plants, on the other hand, this beak is less rigid and often weak, especially at base, so that as the mesocarp matures and contracts, the beak is pulled toward the back and the drying mesocarp forms a false upwardly developed keel. This difference is a real and striking one and, were it consistent, enough to warrant maintaining the two entities as distinct species. But the American plants frequently have the rigid beak (see plate 746, fig. 1), and spikes are occasionally found producing both types. An examination of a large series of the European *P. alpinus* shows that occasionally the beak is curved toward the back and the false upwardly-developed keel is produced. Hultén, who examined many sheets of the European material and who is familiar with the plant as it appears in Asia, says, "The form of the fruits and its beak are subject to considerable variation in the European material" and "the limit between the two types in Central Asia, where they meet, seems

[1] M. L. Fernald, Rhodora 32: 80 (1930).

to be rather diffuse."[1] Because of this intergrading of characters, it seems best to regard the American plants as but varietally distinct from *P. alpinus* of Europe.

The only varietal name applied to the American *P. alpinus* is that of Gray who reduced it, along with a number of other distinct species, to *P. lucens* var.? *fluitans*. As this varietal name was based on *P. fluitans* Roth, it cannot be used here.

P. tenuifolius Raf. is based on the description of "*P. lucens*" in Michaux' Flora[2], and thus the specimen in the Michaux Herbarium at the Paris Museum, on which *P. lucens* sensu Michaux is founded, becomes the type. Two specimens are on this sheet. This has been ably discussed by Fernald[3], who chose the plant on the right to stand as the type of *P. tenuifolius* Raf. From a tracing it was surmised that the plant on the left represents *P. tenuifolius* var. *subellipticus* (*P. alpinus* var. *subellipticus*), but a photograph secured for the writer by Mr. Weatherby of the Gray Herbarium shows it to be *P. gramineus*. However, this in no way affects the typification of *P. tenuifolius* Raf., on which *P. alpinus* var. *tenuifolius* is based.

P. montanense of Gandoger is based upon a specimen which he cites as Rydberg 3724 from Shoshone L., Montana. The collection is Rydberg and Bessey 3724 from Shoshone L., Wyoming, with isotypes in several American herbaria. This collection was distributed as "*Potamogeton Zizii* Roth." Gandoger found it easy to distinguish from *P. Zizii*, so dubbed it a new species, choosing the name from the mistaken idea that it came from Montana. The isotypes seen by me are typical *P. alpinus* var. *tenuifolius*.

In North America, two varieties of *P. alpinus* are recognized which in their typical development are strongly marked and easily distinguished, but with many intergrades. The less common one (var. *subellipticus*) is generally found in shallow water and has a strong tendency to produce floating leaves. At first thought one might consider it to be merely an ecological state of the deep-water plant which is thus approaching the terrestrial condition. Such, however, seems not to be the case, for typical var. *tenuifolius* may be found in shallow water and

[1] Eric Hultén, Fl. Aleut. Is. 65 (1937).

[2] Andreas Michaux, Fl. Bor.-Am. 1: 101 (1803).

[3] M. L. Fernald, Rhodora 33: 210 (1931).

even stranded along the shore, while many specimens of var. *subellipticus* show evidences of having developed in deep water.

3. P. POLYGONIFOLIUS Pourret

RHIZOME buff or pinkish, often with cinnamon spots, about same thickness as stem. STEM simple, .7–2 mm. in diameter; stele with the proto-type pattern; endodermis mostly of O-cells; interlacunar bundles absent; subepidermal bundles present; pseudo-hypodermis 1 or 2 cells thick. SUBMERSED LEAVES (usually absent) with blades lanceolate, 3–10 cm. long, .5–1.5 cm. wide, tapering gradually at both ends, apex acutish but not sharp-pointed, petiole 1–3 cm. long; nerves 7–11, outer ones marginal; lacunae rather obscure, of 2–4 rows each side of midrib; margin entire. FLOATING LEAVES coriaceous, ovate, apex tapering to an obtuse tip, base rounded or slightly cordate, petioles 1–15 cm. long, blades 3–8 (–9) cm. long, 1–4 cm. wide, nerves (11–) 15–19 (–21), all of about equal prominence; lacunae none. STIPULES about 3 cm. long, somewhat persistent, without keels or practically so. PEDUNCLES about same thickness as stem, 4–12 cm. long. SPIKES with about 10 whorls, in fruit 2–3 cm. long, .5–.7 cm. wide. FLOWERS sessile or nearly so; sepaloid connectives greenish, blades orbicular or elliptical, 1–2 mm. wide, claws .3–.7 mm. long; anthers .6–.8 mm. long. FRUITS obovate to orbicular, rounded at base, sides with a depression, especially if immature, (1.6–) 2–2.5 mm. long, (1.2–) 1.5–2.1 mm. wide; beak minute or obsolete; keels absent or nearly so; exocarp reddish; endocarp loop often with a large cavity; apex of seed pointing toward the basal end or slightly above.

P. polygonifolius Pourr., Mém. Acad. Toulouse **3:** 325 (1788); Benn., Bot. Gaz. **32:** 58 (1901); Graebn. in Engler. Pflanzenr., **4:** fam. 11: 65 (1907); Taylor, N. Am. Fl. **17:** pt. 1: 21 (1909); Hagstr., Crit. Res. Pot. 175 (1916).

Shallow pools and muddy brooks. Eastern Newfoundland, St. Pierre Island, and on Sable Island. MAP 4. Europe, northern Africa. NEWFOUNDLAND: George's Brook, near Clarenville, Aug. 1933, *Ayre;* Carbonear, Avalon Pen., *Fernald & Wiegand 4468;* Brigus Junction, Avalon Pen., *Fernald & Wiegand 4467;* Whitbourne, *Robinson & Schrenk 231;* near Portugal Cove, Avalon Pen., *Fernald, Long & Dunbar 26218;* Topsail, *C. S. Williamson 455.* ST. PIERRE ET MIQUELON: Savoyard, St. Pierre, *Arsène 41.* NOVA SCOTIA: Sable Island, 43° 59′ N., 59° 47′ W., *St. John 1121 & 1122.*

P. polygonifolius ranges through Europe, Algeria, Morocco, Madeira and the Azores[1], but appears in the western hemisphere

[1] The old world range of this species is taken from Hagström, Crit. Res. Pot. 178 (1916). It is also given a widespread Asiatic range by Bennett, Bot. Gaz. **32:** 59 (1901).

only in eastern Newfoundland, the island of St. Pierre close by, and Sable Island off Nova Scotia. It may be presumed that this species in America, now confined to areas that largely escaped the last continental glaciation, once had a much wider range.

This species has a strong tendency to produce floating leaves which often spring almost directly from the rhizome. Terrestrial forms are common and in such condition may survive in ponds that dry up for a part of the summer.[1]

4. P. AMPLIFOLIUS Tuckerman

RHIZOMES whitish or often with a reddish cast, 2–4 mm. in diameter, scales black, broadly obtuse. STEM terete, 1–3.5 mm. in diameter, simple or forming short branches late in the season; stele with the proto-type pattern; endodermis of O-cells; interlacunar bundles present throughout; subepidermal bundles absent; pseudo-hypodermis 1 or 2 cells thick. SUBMERSED LEAVES (excluding transition leaves) of two more or less distinct types: those on the lower part of the stem lanceolate, dark green and usually badly decayed by the time the floating leaves appear, with 19–25 nerves: those of the upper part of the stem broadly lanceolate to ovate with margins much longer than midrib giving those leaves just below the floating ones a characteristic arcuate appearance, with 23–37 nerves; both types obtuse or acutish at apex, but never sharp-pointed, and tapering to petioles 1–6 cm. long; blades 8–20 cm. long, 2.5–7.5 cm. wide; margins entire; lacunae 3–6 rows each side of midrib. FLOATING LEAVES with gradual transitions from the submersed ones, coriaceous, opaque, ovate to elliptical, apex rounded or bluntly mucronate, base cuneate or rounded, petioles 8–20 cm. long, blades 5–10 cm. long, 2.5–5 cm. wide, with (21–) 29–41 (–51) nerves, about ¼ of the nerves more prominent than the others, as seen by transmitted light; lacunae none. STIPULES of the submersed leaves somewhat persistent, fibrous, triangular, obtuse when young, becoming twistedly stringy with age, 3.5–11 cm. long, obscurely 2-keeled; those of the floating leaves similar, 5–12 (–18.5) cm. long, with 2 fairly well marked keel-nerves and 30–40 fine nerves. PEDUNCLES at base about same thickness as stem, but usually thicker at the middle or upper half, 4–30 cm. long. SPIKES with 9–16 whorls; in fruit 4–8 cm. long, 1–1.5 cm. thick. FLOWERS sessile or on very short pedicels up to 1 mm. long; sepaloid connectives usually with a reddish cast, sometimes greenish, blades orbicular to elliptical, (1.2–) 1.5–3 (–3.5) mm. wide, claws .4–.8 (–1) mm. long; anthers .8–1.5 (–2) mm. long.

[1] See Harold St. John, Sable Island, etc., Proc. Bost. Soc. Nat. Hist. **36**: no. 1: 59 (1921).

Fruits obovate, rounded on the back, cuneate at base, sides flat, 3.5–4.5 (–5) mm. long (excluding beak), 2.5–3.3 (–3.7) mm. wide, beak often prominent, up to 1 mm. long; keels usually prominent but sometimes rounded or obscure, the dorsal one often strongly developed, especially at the middle; exocarp usually reddish or orange-brown if fully mature, otherwise greenish; endocarp with 3 prominent, acutish and often somewhat muricate keels, beak linear, facial, about 1 mm. long, loop solid; apex of seed pointing .6–1.5 mm. above the basal end. Robust plants characterized by several large arcuate submersed leaves clustered just below the water surface, and floating leaves with numerous nerves.

P. amplifolius Tuckerm., Am. Journ. Sci. ser. 2: **6:** 225 (1848); Morong, Mem. Torr. Club. **3:** no. 2: 16 (1893); Graebner in Engler, Pflanzenr. **4:** fam. 11: 67 (1907); Taylor, N. Am. Fl. **17:** pt. 1: 18 (1909); Hagstr., Crit. Res. Pot. 163 (1916). *P. lucens* var. ? *fluitans* (Roth) Gray, Man. ed. 2: 435 (1856), as to plants included in part, not *P. fluitans* Roth. *?P. amplifolius* forma *amphibius* Benn., Journ. Bot. **42:** 70 (1904). *?P. amplifolius* var. *ovalifolius* Morong ex Benn., Journ. Bot. **42:** 70 (1904); ? Graebn., in Engler, Pflanzenr. **4:** fam. 11: 68 (1907). *?P. amplifolius* var. *amphibius* (Benn.) Graebn. in Engler, Pflanzenr. **4:** fam. 11: 68 (1907). *Spirillus amplifolius* (Tuckerm.) Nieuwl., Am. Mid. Nat. **3:** 16 (1913). *P. amplifolius* forma *homophyllus* Hagstr., Crit. Res. Pot. 163 (1916).

Lakes and streams, usually in deep water. Newfoundland, south to Virginia and Tennessee, west to Missouri and Kansas, also in California, Oregon and Washington. Map 5. The following, selected from many specimens, are representative: Newfoundland: Salmonier R., 1931, *Ayre;* Frenchman's Cove, Bay of Islands, *Mackenzie & Griscom 10045*. Quebec: Lac Sainte-Anne, *Victorin, Rolland & Jacques 33517;* New Richmond, Bonaventure Co., *Victorin, Rolland & Jacques 33858;* Lake Memphremagog, July 29, 1902, *J. R. Churchill;* Rivière-aux-Serpents, Oka, *Victorin 20457, 21201 & 25815;* East Templeton, *John Macoun 85534;* East Templeton near Hull, *Malte 118267 & 118268*. McGregor L., *J. M. Macoun 86002;* Lac Lepêche, *Rolland 13044;* Otter L., Pontiac Co., *Gauthier 2422;* Lac Donaldson, Buckingham, *Rouleau 7231;* Kondiaronk (Lac Creux), *Victorin 16065*. Nova Scotia: Mill Brook, Sheffield's Mills, Kings Co., Aug. 24, 1902, *Fernald;* Young's L., North Mt., Belle Isle, Annapolis Co., *Fernald, Bartram, Long & Fassett 23139;* Lily L., Sandy Cove, Digby Co., *Fernald & Long 19688;* Little Meteghan L., Digby Co., *Fernald & Long 23140;* Sloane L., Pleasant Valley, Yarmouth Co., *Fernald*, et al. *19689*. Maine: Saint Francis R., Aroostook Co., Aug. 13, 1902, *Eggleston & Fernald;* St. John P., T. 6, R. 17, Somerset Co., *St. John &*

Nichols 2108; Eagle L., Piscataquis Co., *Ogden 1704;* E. Eddington, Penobscot Co., Aug. 21, 1897, *Fernald;* Harvey's P., Levant, Penobscot Co., *Ogden & Marston 1693, Plantae Exsiccatae Grayanae 904;* Loon L., Franklin Co., 1894, *Furbish;* Middle P., S. Poland, Androscoggin Co., Sept. 1893, *Furbish.* NEW HAMPSHIRE: Lime Pond, Columbia, Coös Co., *Pease 13883;* York P., Kilkenny, Coös Co., *Pease 17185;* Burns P., Whitefield, Coös Co., *Pease 14585,* also *Moore 5036;* Wolfboro, Carroll Co., *R. A. Ware 3326;* Squaw Cove, Squam L., Sandwich, Carroll Co., July 21, 1923, *Svenson;* Dublin, Cheshire Co., Aug. 8, 1931, *Eaton & Griscom;* Johnson Creek, Madbury, Strafford Co., *Hodgdon 2652.* VERMONT: Little Leech P., Averill, Essex Co., *Eggleston 1655;* Long Pond, Willoughby, Orleans Co., July 26, 1896, *Kennedy;* Willoughby L., Aug. 31, 1917, *E. J. Winslow;* Missisquoi Bay, Lake Champlain, Swanton, Franklin Co., Sept. 14, 1909, *A. E. Blewitt;* Spectacle L., Rutland Co., July 21, 1907, *E. C. Kent;* Big P., Rutland Co., Aug. 29, 1895, *E. C. Kent;* Chittenden, Aug. 18, 1895, *Eggleston.* MASSACHUSETTS: Wenham P., Wenham, Essex Co., July 13, 1895, *J. H. Sears;* Fresh P., Cambridge, Middlesex Co., many collectors; Concord R., Billerica, Middlesex Co., *Fernald & Abbe 2506;* Sudbury R., Concord, Middlesex Co., Aug. 4, 1886, *Morong,* also Aug. 4, 1886, *Deane,* also *Ogden & Wiggins 1729;* Wood's P., Wellesley, Norfolk Co., Aug. 1, 1881, *Morong;* Middleboro, Plymouth Co., Aug. 12, 1901, *J. Murdock;* Quinsigamond P., Worcester, June 29, 1864, *Robbins;* Great Brook, Southwick, Hampden Co., *Seymour 249;* Spectacle P., Sandisfield, Berkshire Co., June 27, 1912, *R. Hoffmann;* Egremont, *Standley & Killip 7648.* RHODE ISLAND: Pawtuxet R., Cranston, Providence Co., July 6, 1898, *J. F. Collins;* Apponaug P., "Kingston," [Apponaug Pond is in the town of Warwick] Washington Co., Aug. 26, 1880, *Morong.* CONNECTICUT: Thompson, Windham Co., June 10, 1922, *Eaton & Fassett;* East Granby, Hartford Co., *Weatherby D2409;* Hamlins P., Plainville, Hartford Co., *Blewitt 632;* Quinnipaug P., Guilford, New Haven Co., Sept. 1886, *W. R. Dudley;* Seldens Cove, Lyme, Aug. 29, 1901, *C. H. Bissell;* Mudge P., Sharon, *Weatherby & Anderson 5901;* Colebrook, Aug. 13, 1850, *J. W. Robbins;* West Goshen, Aug. 1892, *L. M. Underwood;* Twin Lakes Station, Salisbury, Litchfield Co., Aug. 20, 1935, *Fernald & Ogden.* NEW YORK: Mouth of Perch River, Jefferson Co., *Muenscher & Maguire 1600;* Spencer Lake, Spencer, Tioga Co., *Eames & Wiegand 11172;* Pierrepont P., Woodville, *House 8838,* also *Ogden & Bolan 1583;* Indian L., Franklin Co., *Muenscher & Maguire 719;* Eagle L., Essex Co., *Killip 12610;* Bemus Point, Lake Chautauqua, Aug. 8, 1896, *Churchill;* Edick Creek near Sears P., Lewis Co., *Hotchkiss 2646;* Rockland L., July 17, 1892, *Morong;* Carpenters P., Fabius, Onondaga Co., *House 1329;* Waldorf P., s. of North

Chatham, Columbia Co., *House 21752;* Pine P. (Gypsy L.), Putnam Co., *Muenscher & Curtis 5423;* Sodus Bay, *Killip 12261;* Lake Luzerne, Luzerne, Warren Co., *Fogg 4934;* Hudson R., Coveville, Saratoga Co., *Muenscher & Lindsey 2723;* North Harpersfield, Delaware Co., *Topping 203.* NEW JERSEY: Delaware R., Camden, Oct. 7, 1877, *C. F. Parker;* Pensauken, Camden Co., *Adams & Trudell 378;* Swartswood L., Sussex Co., *Griscom & Mackenzie 10679;* Cranberry L., Sussex Co., *Mackenzie 2305;* Sparta, Sussex Co., Sept. 13, 1887, *N. L. Britton;* Hackensac R., Bergen Co., July 25, 1861, *C. F. Austin.* PENNSYLVANIA: Martin's Creek, Northampton Co., Aug. 29, 1906, *C. S. Williamson;* Lehigh above Easton, June 15, 1869, *Thos. C. Porter;* near Peekskill, West Chester Co., 1868, *LeRoy;* Brandywine Creek, Icedale, Chester Co., Sept. 18, 1927, *H. E. Stone.* DISTRICT OF COLUMBIA: near Washington, *Coville 129;* Eastern Branch below Navy Yard, Sept. 1, 1900, *E. S. Steele.* MARYLAND: Mouth of Mill Creek, Chesapeake Bay Region, *G. H. Shull 97.* WEST VIRGINIA: Minnehaha Springs, Pocahontas Co., July 31, 1930, *W. V. U. Bot. Exped.;* also *E. E. Berkley 1387;* Huttonsville, Randolph Co., *Moore 2488.* VIRGINIA: Four Mile Run, *Shull 413 & 473;* June 6, 1899, *E. S. Steele;* Dyke, Fairfax Co., *Metcalf & Sperry 1621, 1634, & 1639;* Hunting Creek, Dist. of Columbia and vicinity, *McAtee 2237 & 2279.* GEORGIA: Lafayette, Walker Co., *Wilson 189.* ONTARIO: Plevna, Aug. 19, 1902, *J. Fowler;* Epilobium Bay, Bear Island, *Watson 1178;* Whitney L., 12 mi. n. of Temagami, *Kane 1030;* Bass Creek, Franks Bay, Lake Nipissing, *Chitty 319;* McGregor Bay, Manitoulin District, *Ogden & Bolan 1647;* Gore Bay, Manitoulin Island, *Pease & Ogden 25032;* Old Woman's R., Bruce Pen., *Krotkov 8629;* Gull L., Addington Co., July 15, 1870, *John Macoun;* Belleville, Hastings Co., July 1876, *John Macoun;* Lac Meach, Ottawa, *Rolland 8697.* MICHIGAN: Isle Royale, *Cooper 93 & 215;* Lake Manganese, Copper Harbor, Keweenaw Co., *Hermann 8233;* Carp R., Porcupine Mts., Aug. 16, 1923, *H. T. Darlington;* Crystal Falls, Iron Co., *Metcalf 2242, 2250, 2254 & 2255;* Michigamme L., Iron Co., *Metcalf 2209 & 2210;* Whitefish L., Mackinac Co., *Metcalf 2321;* Chassell, Houghton Co., *Pease & Ogden 25167;* Black L., Cheboygan Co., Aug. 3, 1935, *Gleason;* Little Manistee R., Manistee, Aug. 8, 1882, *Morong;* Washtenaw Co., July 17, 1838, *Houghton;* Mill-pond, Alma, Aug. 11, 1893, *C. A. Davis;* Kalamazoo R., Allegan Co., *Wight 97 & 109;* Kimble L., Vicksburg, Kalamazoo Co., July 5 & 28, *F. W. Rapp;* Sister Lakes, Van Buren Co., *De Selm 24* (F, mixed with *P. natans*); Papaw L., Berrien Co., *Dodge 172;* Haslet, *Yuncker 361.* OHIO: Geauga L., Portage Co., *Webb 546;* Phalanx, Trumbull Co., *Webb 452;* Cowles Creek Marsh, Ashtabula Co., Aug. 15, 1894, *Goodrich 209;* East Harbor, Ottawa Co., Aug. 10, 1898, *E. L. Moseley;* Put-in-Bay, Aug.